A McGRAW-HILL PUBLICATION DECEMBER 1960
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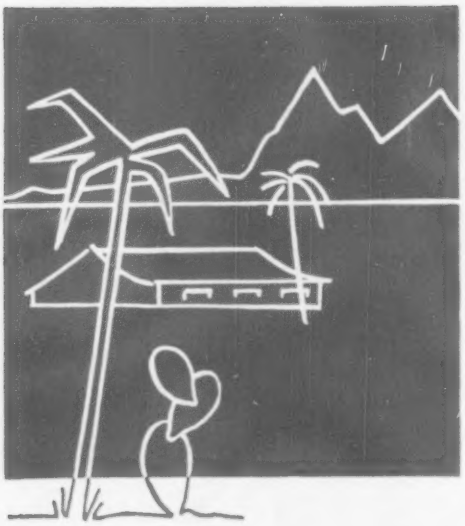
Power

the magazine of energy systems engineering

Air Pollution

a 48-p special report • 67

AEG



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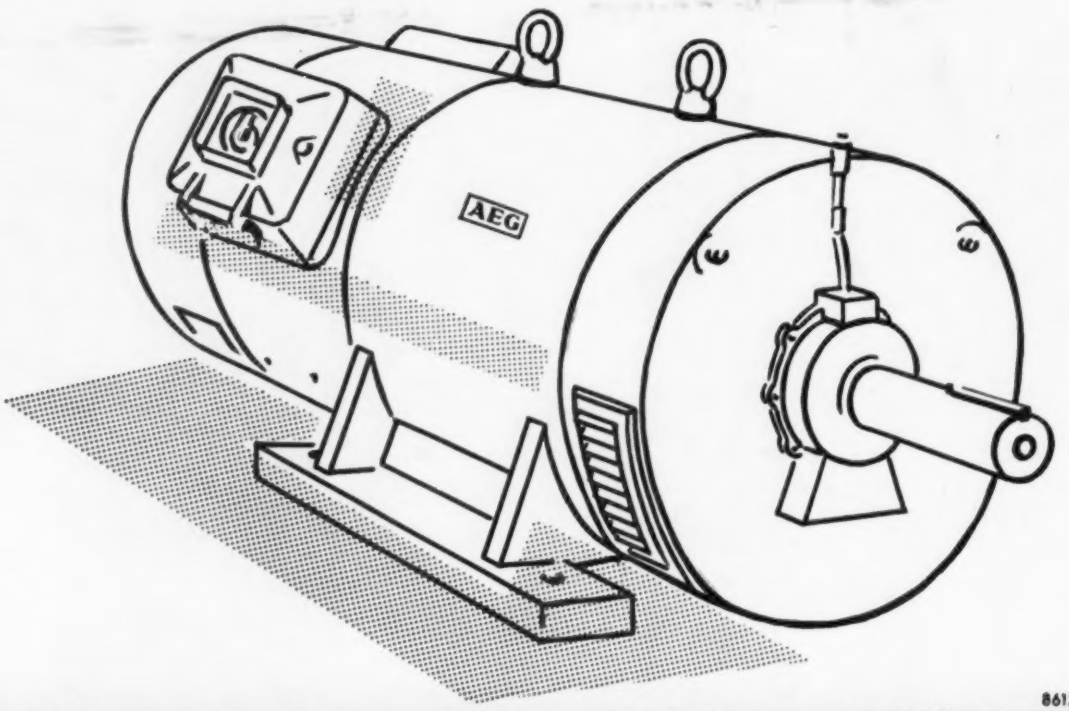

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16,000 engineers can't be wrong!

Over the last 50 years, engineers of more than 16,000 steam plants have specified and used Yarway Seatless Blow-Off Valves.

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They know that . .

Savings in maintenance costs . . .
Freedom from boiler outages . . .

have repaid over and over again the cost of Yarways!

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NO SEAT TO SCORE, WEAR, CLOG OR LEAK!

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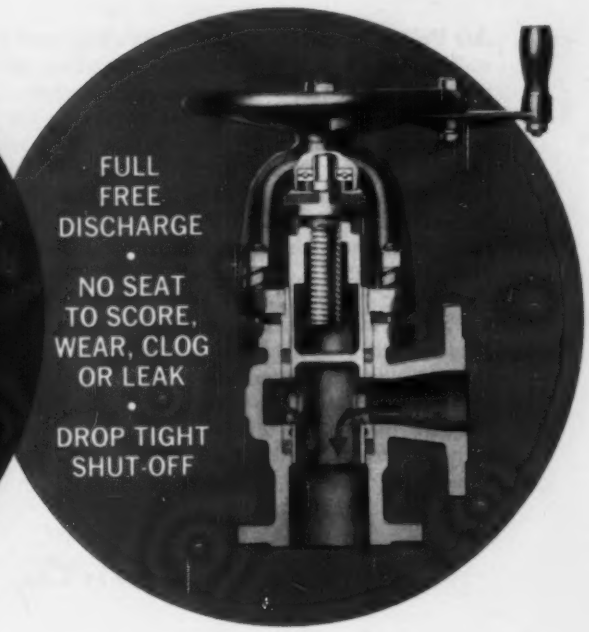

Typical installation of Yarway Seatless Blow-Off Valves

A FEW OF MANY BOILER MANUFACTURERS STANDARDIZING ON QUALITY YARWAY BLOW-OFF VALVES

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YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

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speaking of **Power**

BENLINE, SKROTZKI, (arm extended) and MicroRingelmann

Air Pollution, subject of this month's 48-p special staff report, kept POWER editors researching for many months. They talked with plant designers, operators, meteorologists, scientists, physicians, law-enforcement officials and others who are, or should be, concerned with the purity of the air man breathes. On one call, Associate Editor Ben Skrotzki talked over use of POWER's MicroRingelmann smoke-measuring chart with Arthur J Benline, New York City's Commissioner of Air Pollution Control, photo above. New York and other cities around the world find daily use for the chart.

Incidentally, the photo shown above will appear in full color, spread over an entire page, in the December 24th issue of *Business Week*. It will help illustrate how editors of POWER, and other McGraw-Hill magazines, take a role of leadership in serving their millions of readers.

Lon Lowley

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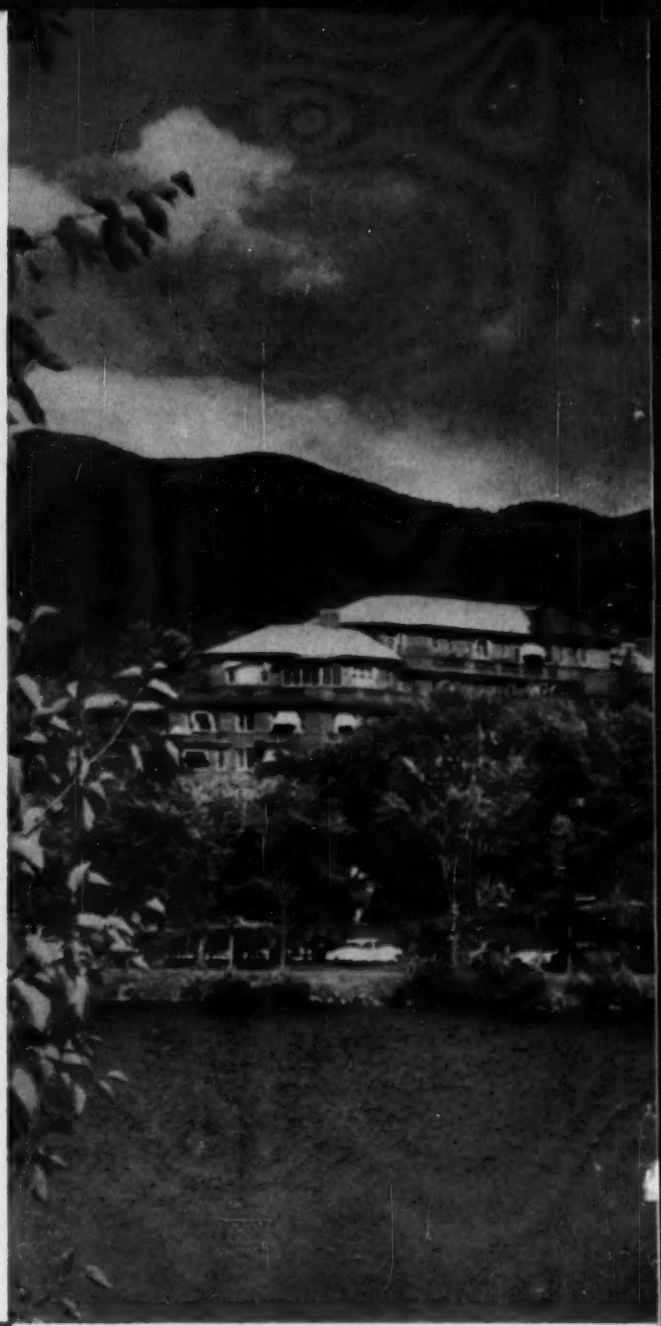
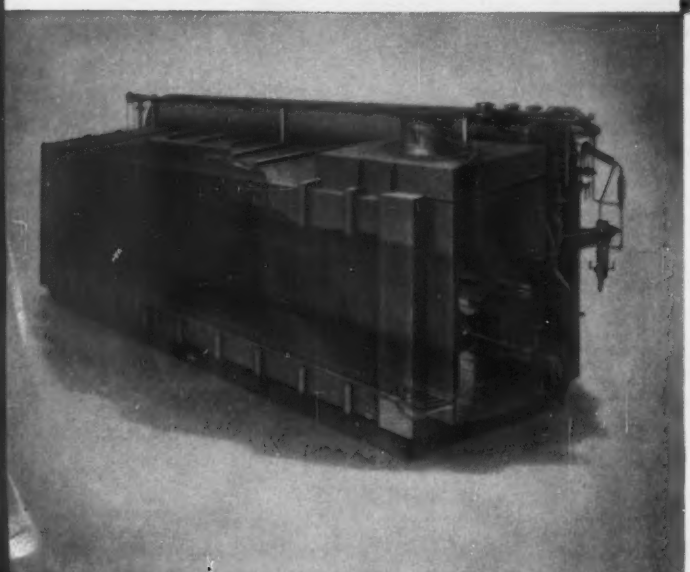
Lake Placid Club Members and Guests are Three Times Cozier via Steam Generation by B&W





Renowned winter resort generates own steam for heating, electric power and laundry . . . finds surest answer in dependable B&W Package Boiler.

At the Adirondacks' famous Lake Placid Club, steam plays a vital role in maintaining an atmosphere of relaxation and comfort for members' and guests' enjoyment. The Club's appealing air of seclusion is won in part by privacy of location . . . so that vital heat, electricity and laundry-steam must come entirely from the Club's own facilities. The Club can also supply power in emergencies to the local hospital and fire department . . . so boiler dependability and ease of operation are critical factors in meeting these crucial and expanding steam requirements. That's why the Club added a B&W Package Boiler. With a steam capacity of 30,000 lb per hr at an operating pressure of 250 psi with superheat to

450 F, this automatically fired unit will give efficient, economical service over a wide load range. And the Club knows that at any time in the life of the boiler—10, 20 or 30 years from now—B&W's nationwide service organization will be promptly and economically available if needed.
Providing these vital steam services for a rambling Adirondack year 'round vacation Club is further evidence-in-action of dependable steam generation by B&W. Whatever the steam requirement . . . whatever fuel is most economical . . . B&W can fill the bill. Your local B&W representative has all the fuel facts on *your* area. Call him soon. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

B&W—THE NATION'S LEADING MANUFACTURER OF INDUSTRIAL BOILERS

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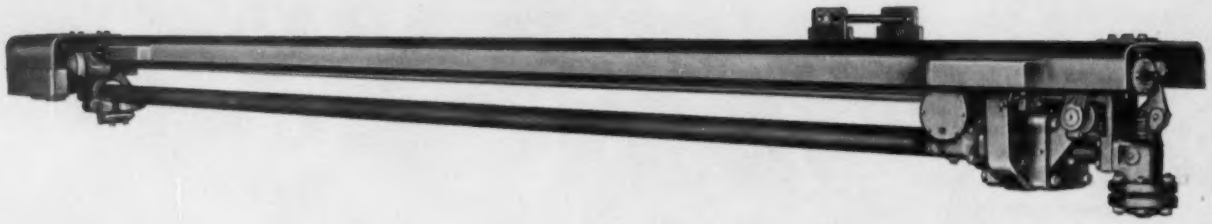

Diamond developed for more economical power...

CHEMICAL CONTROL

Lower fuel costs . . . reduced boiler outage . . . minimum manual cleaning . . . inhibited tube corrosion—these are dramatic savings achieved by Diamond Chemical Slurry Spraying Systems, a revolutionary method of controlling and removing tube deposits generated by burning oils high in vanadium, sodium and sulphur content.

Service tested on some 40 installations, Diamond Slurry Spraying offers a distinct economic advantage over fuel additives because it treats only that ash which collects on the tubes. Magnesium oxide-based slurry is sprayed on heating surfaces by conventional soot blowers modified to discharge, in alternate cycles, both the normal cleaning medium and slurry. The chemical slurry coating changes chemical composition of deposit so that it's easily removed by normal blowing.

If you burn — or are considering burning low-grade oil, it will pay you to take a close look at Chemical Slurry Spraying . . . another Diamond-Developed Boiler Cleaning System. At your request, our engineers will make recommendations based on your specific requirements. Call, write or wire for complete information.

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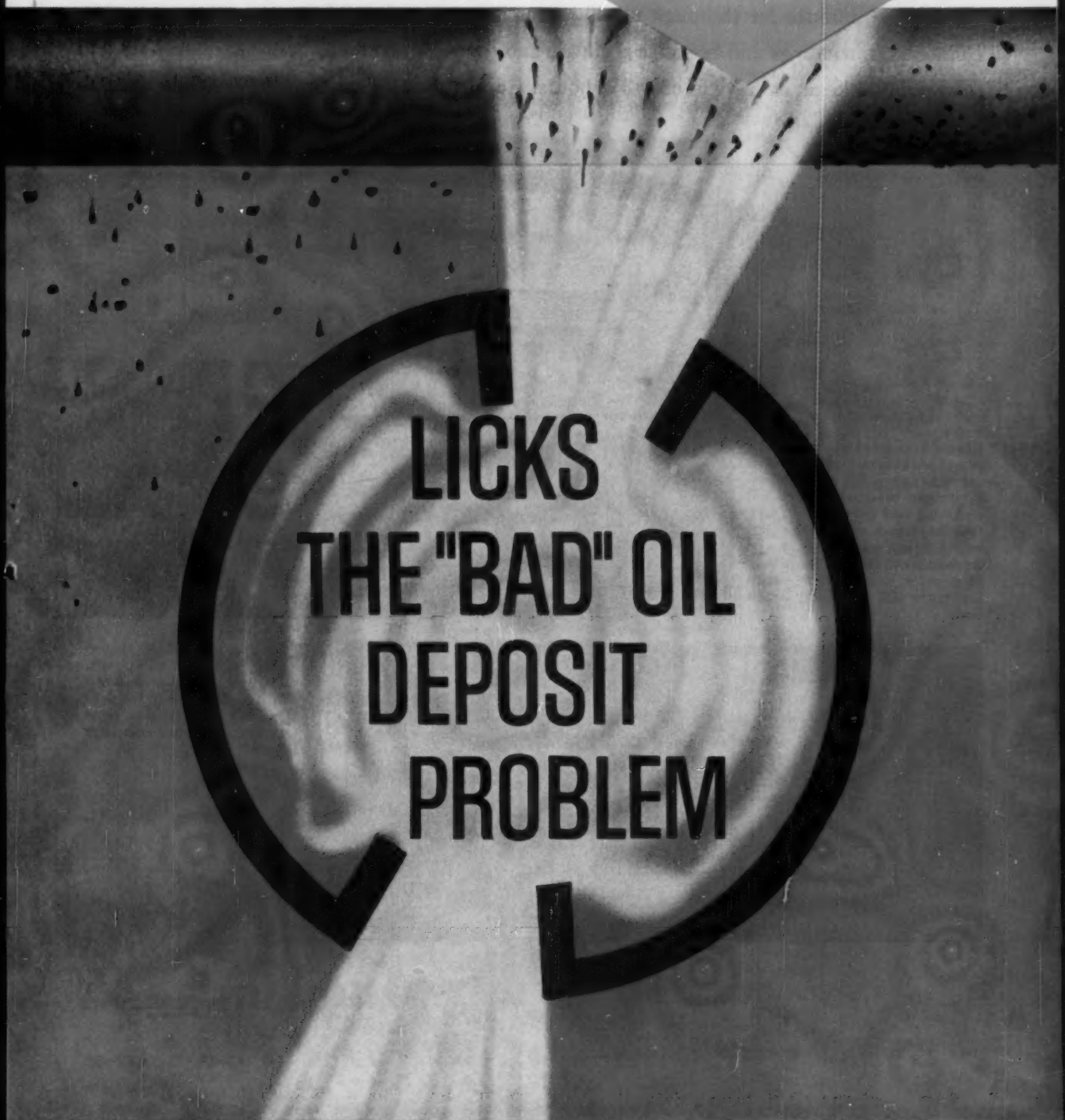
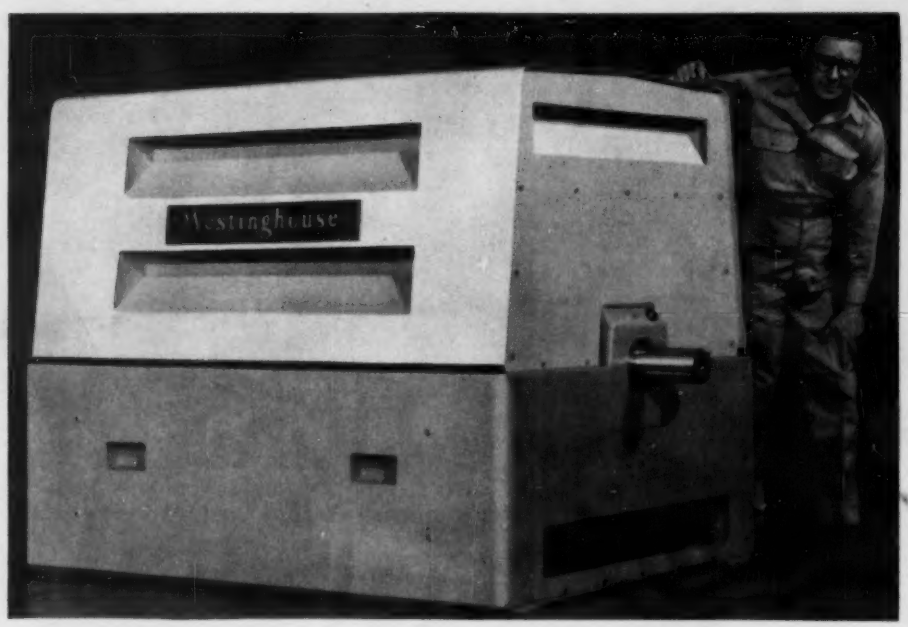


More Value For Your Large Motor Investment . . .

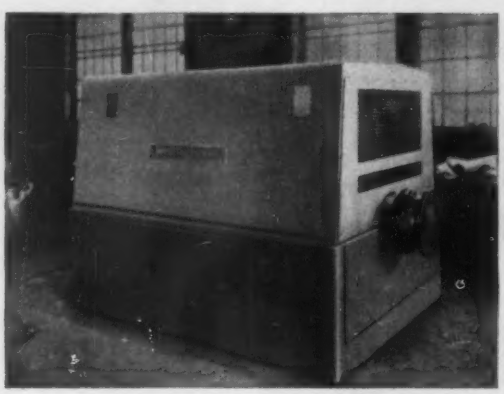
Westinghouse F/A Motor design

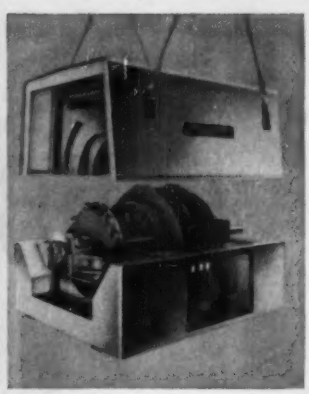
There's an F/A Motor enclosure to meet any of your installation requirements with standard horizontal drip-proof construction . . . NEMA weather-protected enclosures for normal *and* totally unprotected outdoor locations . . . totally enclosed fan-cooled tube-type motors and those having a cooler or heat exchanger.

Each sturdy F/A Motor enclosure is completely separate from the stator and can be removed in minutes for thorough visual motor inspection. In addition, inspection of leads, connections, windings and bearings is simple and quick . . . complete motor disassembly and reassembly take an average of only 3½ hours! Result: unmatched accessibility. This accessi-



Standard horizontal drip-proof enclosure for F/A Motors (at right) gives full accessibility. Cover can be quickly lifted off; removing end panels allows routine inspection of windings and bearings; end panels, covers and air shields can be removed in only 38 minutes, replaced in 56—with the motor still in running condition.





TEFC tube-type F/A Motor enclosure is shown at far left. The tubes are all mounted in top of enclosure, as shown in the next picture, and the motor is completely accessible when enclosure is removed.

YOU CAN BE SURE...IF IT'S

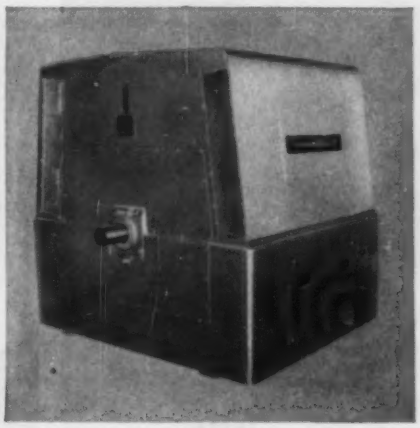
wraps economies in a variety of enclosures

bility, coupled with the time-tested and -proved reliability of Westinghouse motor components, can save you up to 75% on inspection and maintenance.

THAT'S NOT ALL. F/A Motors have unique Thermalastic® insulation which has been protecting coils in more than 50,000,000 kw of Westinghouse large rotating apparatus. Extensive testing shows that Thermalastic has a probable 100-year life. And F/A Motors are super-quiet . . . virtually eliminate the annoying whine typical of large motors.

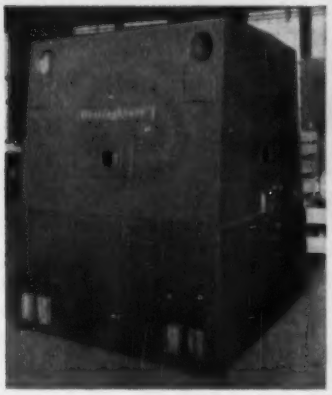
Check today for full information on Westinghouse F/A Motors. Your nearest Westinghouse representative has details . . . or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

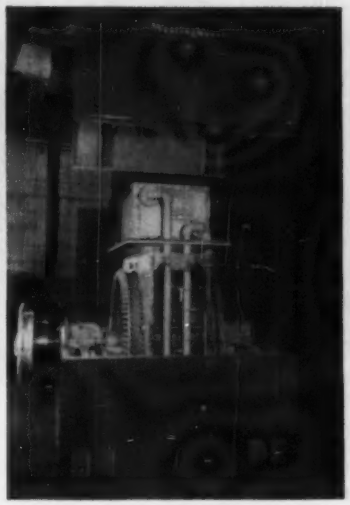
J-15018



Weather-protected enclosures: At left is the NEMA Type I weather-protected F/A Motor that's perfect for normal outdoor installations.

Right, a NEMA weather-protected Type II F/A Motor enclosure which provides maximum protection where adverse weather conditions prevail.





Enclosure for motors with cooler: Note the cooler is inside the enclosure, which can be quickly taken off to expose the cooler and internal motor components as demonstrated at right. Full accessibility of all F/A Motors means substantial savings on inspection time and dollars.

Westinghouse

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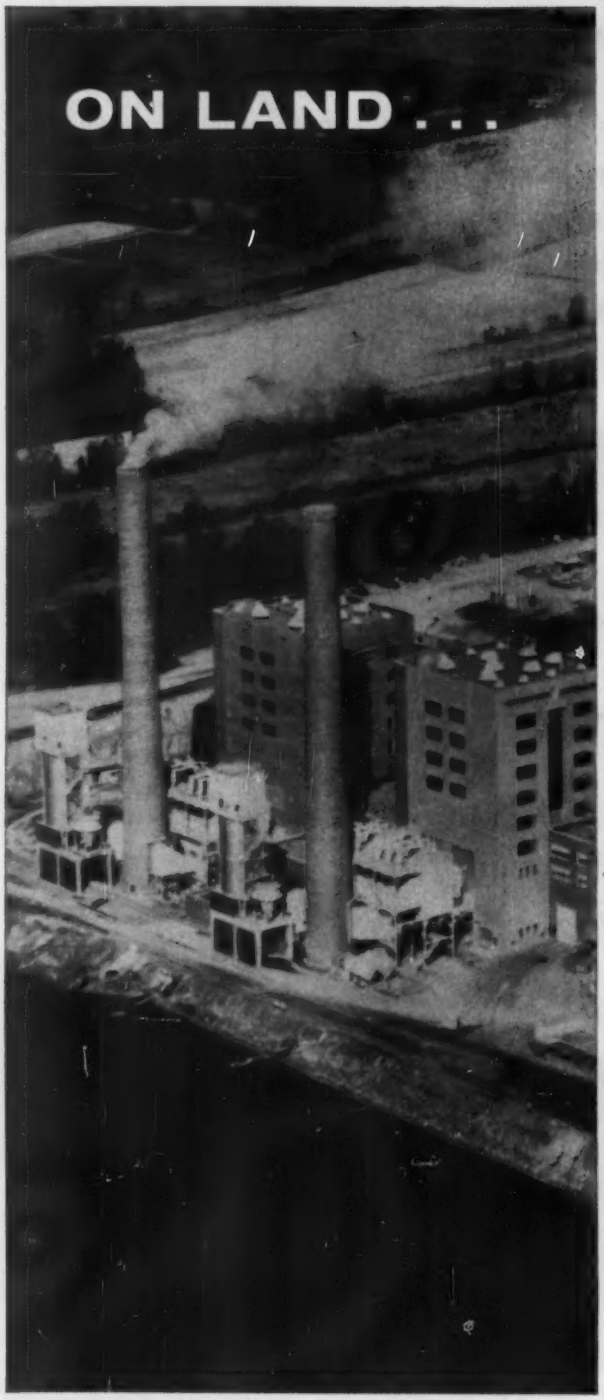
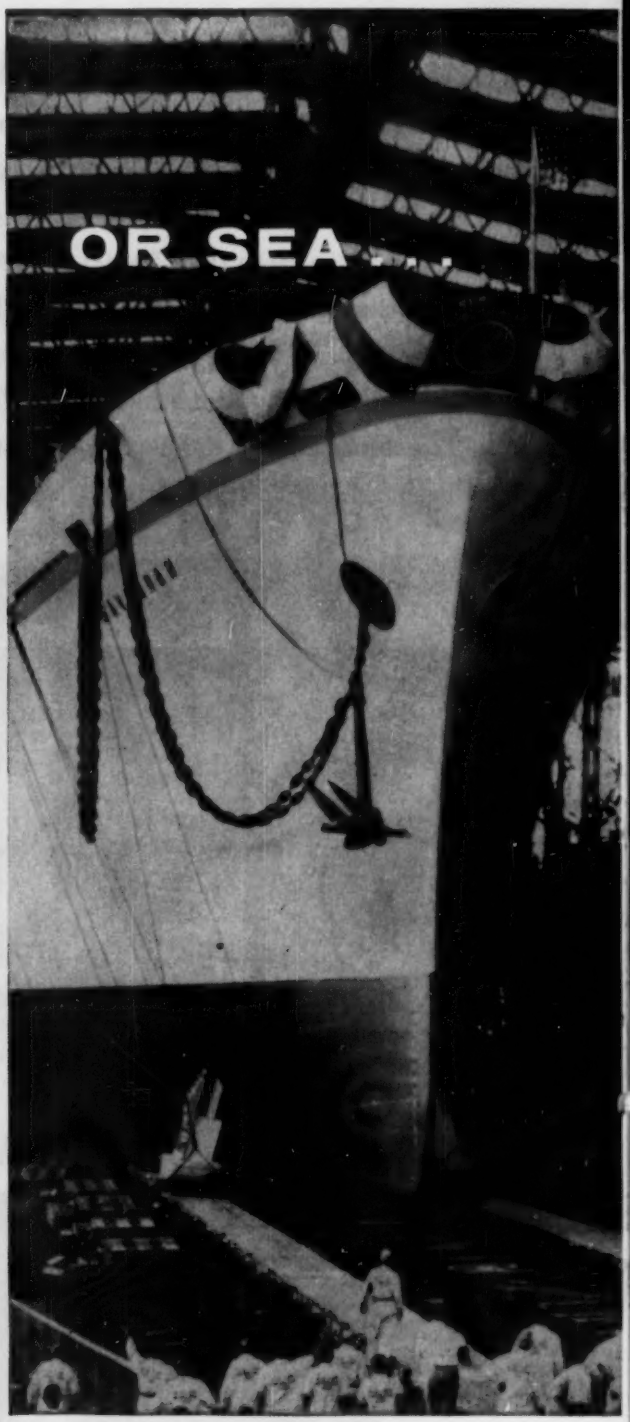


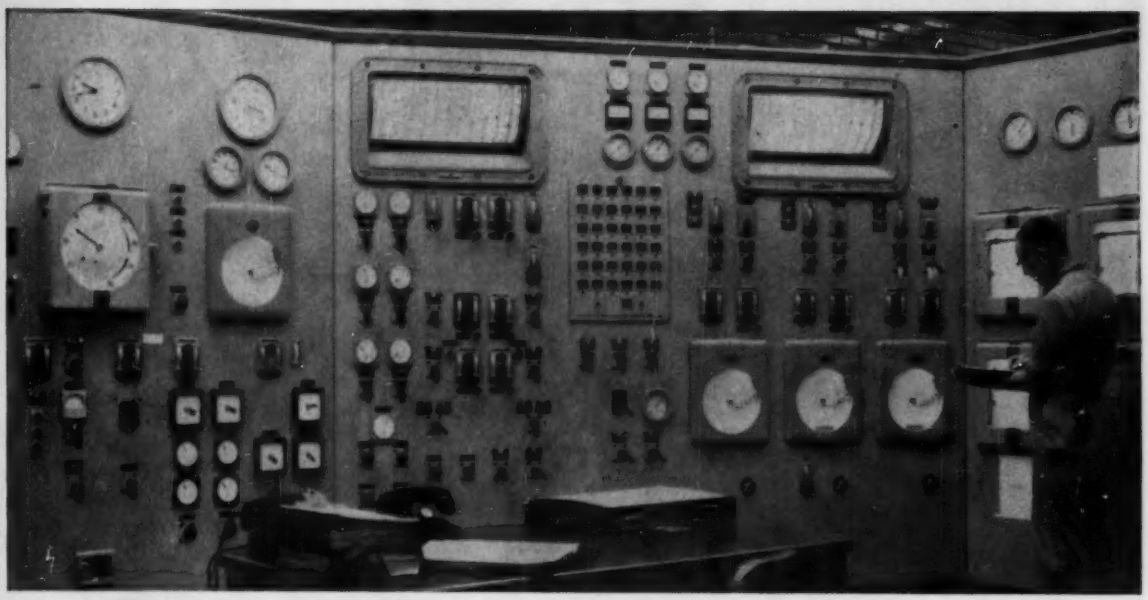
At Milliken Station, New York State Electric and Gas Corporation, Bailey METROTYPE Information Systems monitor operating conditions and gather performance data. The monitoring system continuously scans all points and prints out any off-normal measurements while the performance system makes hourly logs and simultaneously produces punched tape for future use in standard digital computing facilities.



The NS Savannah, first Nuclear merchant ship, is controlled from a "Bailey Board" which includes Nuclear Instrumentation and Bailey Reactor Controls as well as Bailey Steam Plant Instruments and Controls.

This is the control center for the first commercial super-critical pressure, steam-electric unit in America. Here at the Philo plant of the Ohio Power Company, on the American Electric Power Company System, Bailey controls maintain the desired rate of steam generation, final steam temperature and optimum combustion conditions.

IT'S BAILEY. . .



for the latest and safest instruments and controls for nuclear and conventional power plants!

Many of the power plants of the future will have controls and instruments designed and built by Bailey. There are two reasons: Bailey's continuing research and development toward the latest equipment for industry's needs; Bailey's 40-year association with the hardware and economic requirements of the industry.

If you are planning new or improved power plant facilities, call on Bailey engineers to insure that your system will have the *proper balance both as to economics and needs . . . that there will not be the unnecessary expense of over-instrumentation or control . . . nor the duplication of equipment functions.*

Call on Bailey for primary sensing devices, indicators, loggers, control units, panels, data handling equipment, computers for performance analysis, and supervisory controls. You'll find designs ranging from conventional to the most sophisticated . . . mechanical, pneumatic, electric and electronic, including solid state.

There's a Bailey District Office or Resident Engineer close to you. Check your phone book, or write direct.

A143-2

Instruments and controls for power and process

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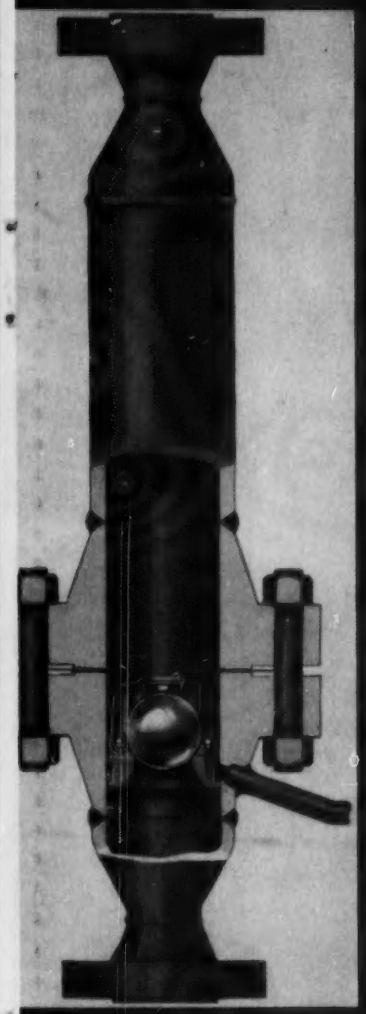
H. J. Heinz relies on Copes-Vulcan reducing and desuperheating station to handle big changes in steam demand



(Far left) **Chart on left side of panel** shows wide load changes. Chart on right indicates exacting pressure and temperature control. Station takes boiler steam at 600 psig and 750 degrees F. and delivers it to process at 110 psig and 360 degrees F.

(Cutaway at left) **A weighted steel ball** controls orifice opening, speeds intimate mixing of cooling-water and steam. No atomizing steam, spray nozzle, or glands required. Write for Bulletin 1027.

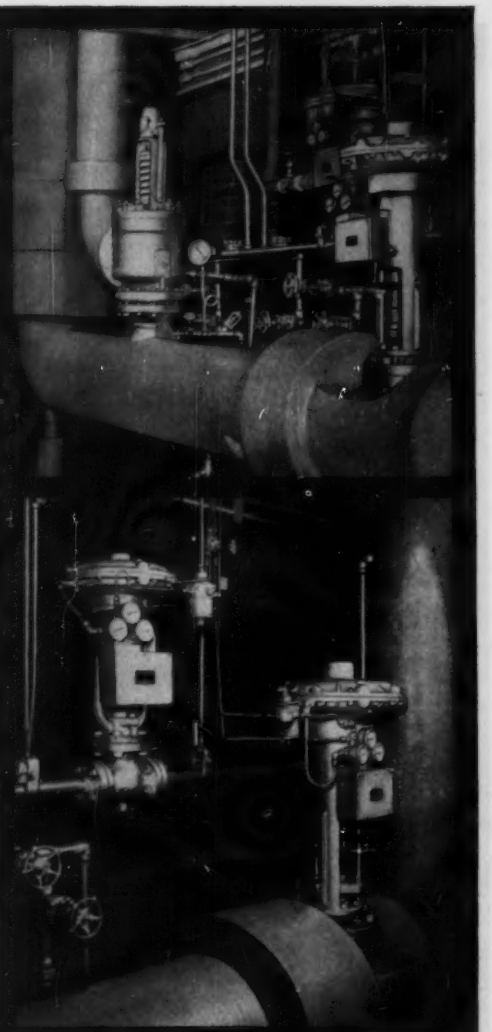
(Upper right) **The 8-inch, 300-pound pressure desuperheater** is installed in the insulated vertical run of steam piping at the far left. The cooling-water control valve is behind the pressure reducing valve in the right foreground.

Fast acting valves assure rigid control

Cooling water flow for the desuperheater is controlled by a 1-inch, 300-pound standard Type CV-D diaphragm valve (left) actuated by a temperature controller.

The 600-pound standard Type CV-D reducing valve (right) has a 4-inch inlet and 8-inch outlet to take care of steam expansion at reduced pressure. Its positioner assures accurate control modulation.

Copes-Vulcan diaphragm type valves can be direct or reverse acting. Piston types are also available for high duty service, assure maximum power with precise positioning. Write for Bulletin 1027.



Working with flow rates that vary from 0 to 70,000 pounds per hour, this Copes-Vulcan reducing and desuperheating station holds process steam to plus-or-minus 4 psig and plus-or-minus 5 degrees F. with only 16 degrees F. superheat. Wide fluctuations in steam requirements often occur extremely rapidly at the H. J. Heinz plant in Pittsburgh. On a typical day, the load increased from 0 to 47,000 pounds per hour within 15 minutes, then dropped back to 5,000 pounds per hour in even less time.

Made up of a Copes-Vulcan Variable-Orifice desuperheater and diaphragm operated Type CV-D valve, this type of station represents a new approach in process steam control. Since its installation over a year ago, the station has maintained an outstanding record for continuous accuracy.

Whatever your operating conditions, Copes-Vulcan has the desuperheating station for controlling your reduced steam temperatures. Besides the Variable-Orifice type, the line includes a Steam-Assist type and a Carburetor type. Write for details.

Copes-Vulcan Division, Erie 4, Pennsylvania.

Copes-Vulcan Division

BLAW-KNOX

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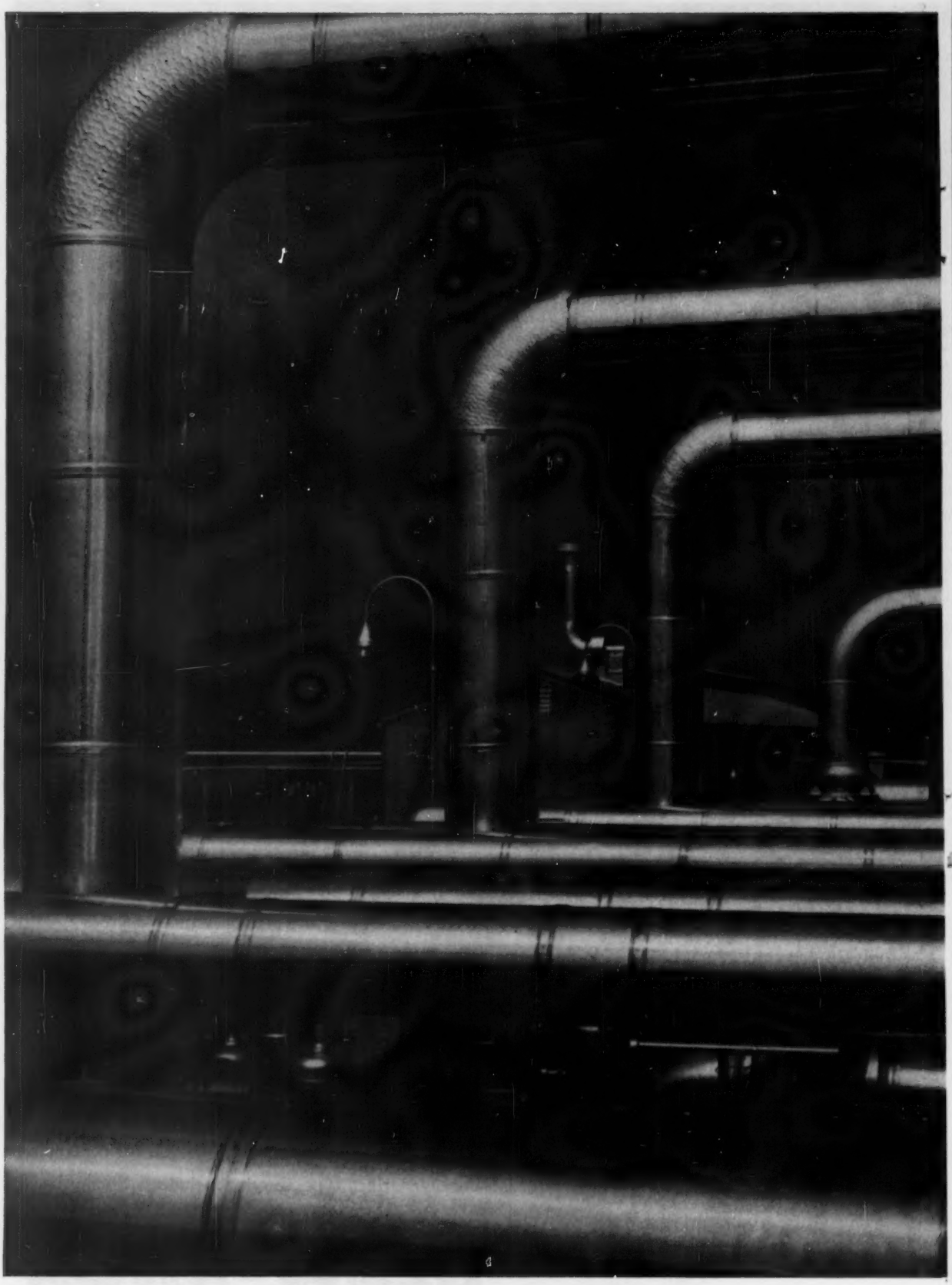


PHOTOGRAPHED AT NEW YORK STATE NATURAL GAS CORPORATION'S LEIDY COMPRESSOR STATION, TAMARACK, PA.

Installation time at Leidy Station cut 25% with prejacketed J-M METAL-ON® pipe insulation!

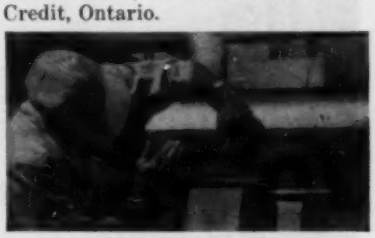
"ALMOST 2 MILES OF METAL-ON PROTECTS OUR OUTDOOR PIPELINES. THIS IS THE BEST–AND BEST-LOOKING–INSULATING JOB I'VE EVER SEEN."
says head station engineer VICTOR CUMMINGS

Leidy Pool, with an ultimate storage capacity of 105.6-billion cubic feet of natural gas, is served by a compressor station incorporating almost two miles of outdoor pipelines. Both lines and equipment must be completely protected against northern Pennsylvania's violent winter storms, torrential spring rains and summer heat. Metal-On jacketing, developed by J-M, was chosen to handle this difficult job.

Metal-On is prefabricated at the factory in 36-inch lengths. Each length combines high-temperature J-M Thermobestos insulation . . . a moisture barrier . . . and a special aluminum alloy jacket. And because each length can be applied in one simple operation, erection time savings at Leidy averaged 25%! Metal-On can also be easily cut on the job with portable power or hand saws. Cutouts for hangers and supports are simple to make.

Maintenance savings can be very impressive, too. Metal-On doesn't corrode, needs no painting. The rugged jacketing, combined with a locking device that snaps closed and seals joints, will lock out weather and moisture permanently. And each section can be easily removed for trouble-shooting.

You may not have *two miles* of pipeline . . . but if you have a tough outdoor insulation problem, it will pay you to investigate J-M Metal-On. Just write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.



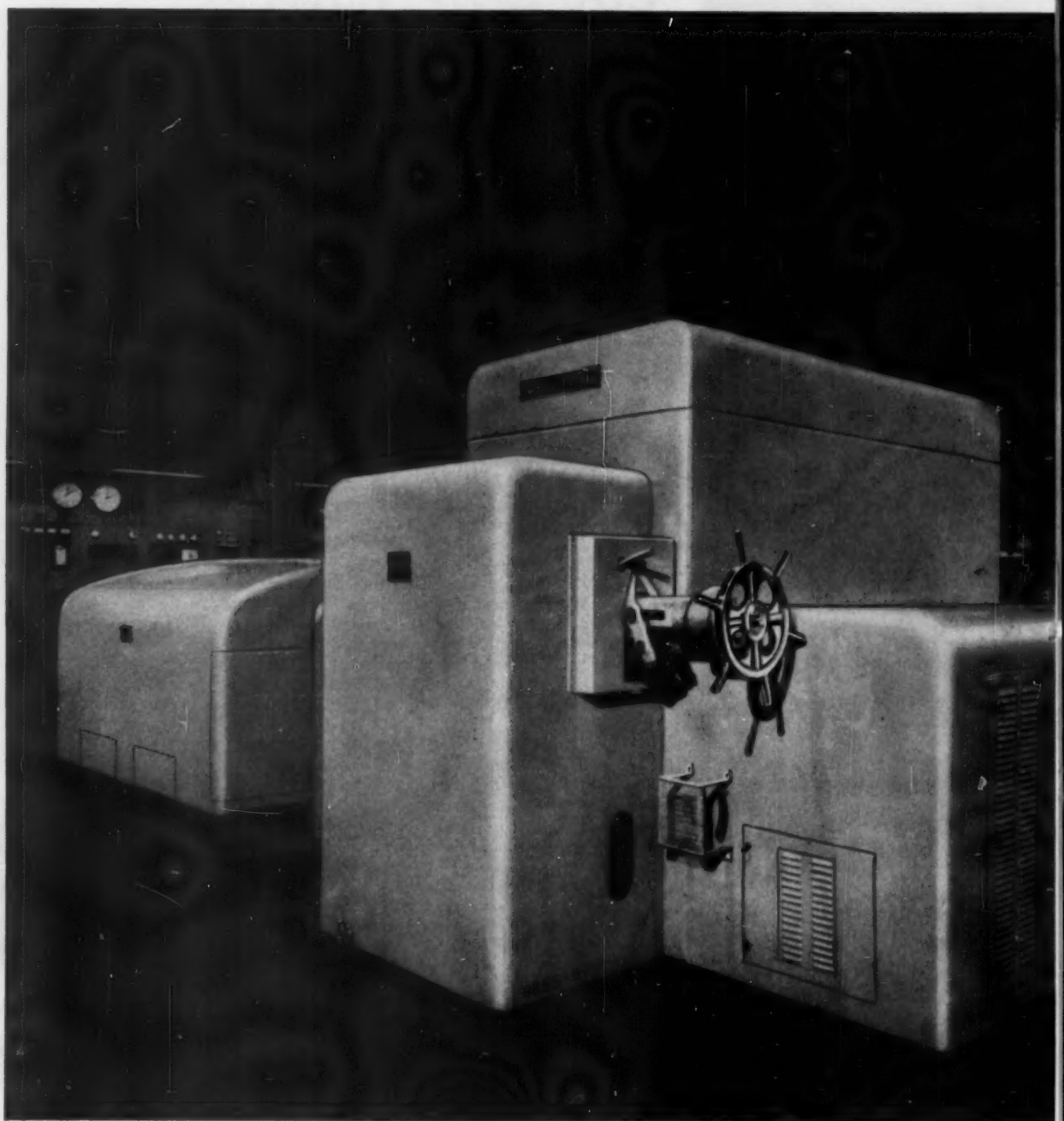
METAL-ON:
JUST MINUTES FROM CARTON TO PIPE!

JOHNS-MANVILLE
AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

JOHNS-MANVILLE JM PRODUCTS

For more facts circle 210 on Reader Service card, p 139

DE LAVAL provides power and process steam

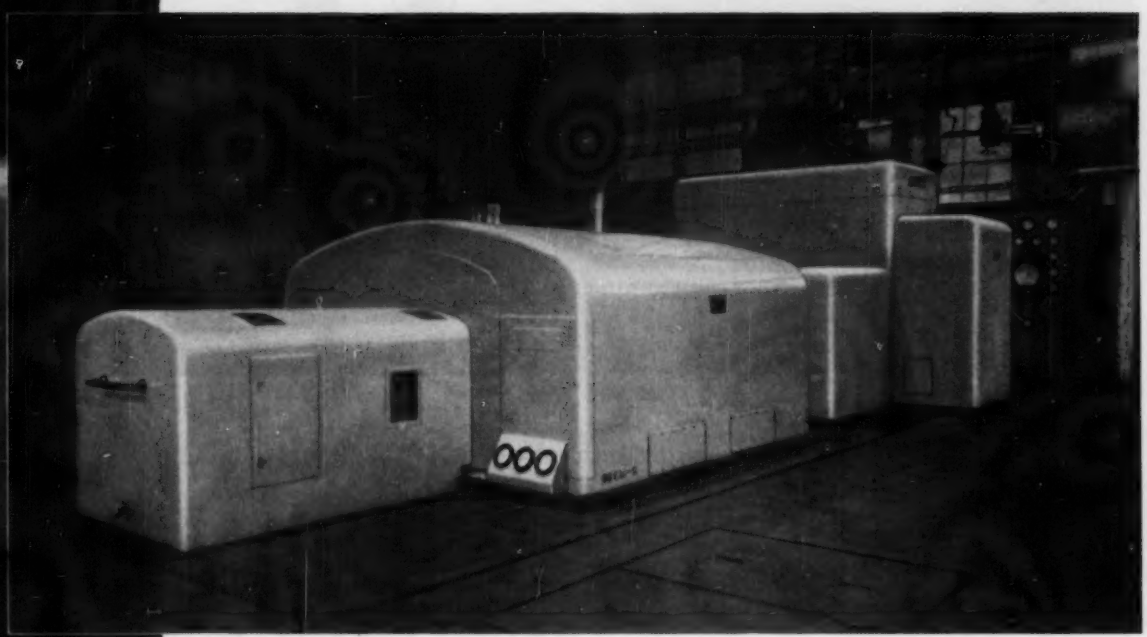


economical
for Corn Products Company

Sargent & Lundy, Consulting Engineers, handle project for new 9375 KW unit.

De Laval design engineers are specialists in meeting unusual requirements. For example, this unit at the Corn Products plant in Pekin, Illinois, is presently operating with 400 psig ISP at 580 F, with 6 stages to develop 5000 KW at a back pressure of 165 psig. Flexible De Laval design will enable this turbine to operate under new steam conditions with 11 stages for which space has been provided in the casing. When operating at its future steam conditions of 850 psig ISP, 700 F, the turbine will develop 9375 KW and will provide 275,000 pounds of steam per hour to the process at a pressure of 165 psig.

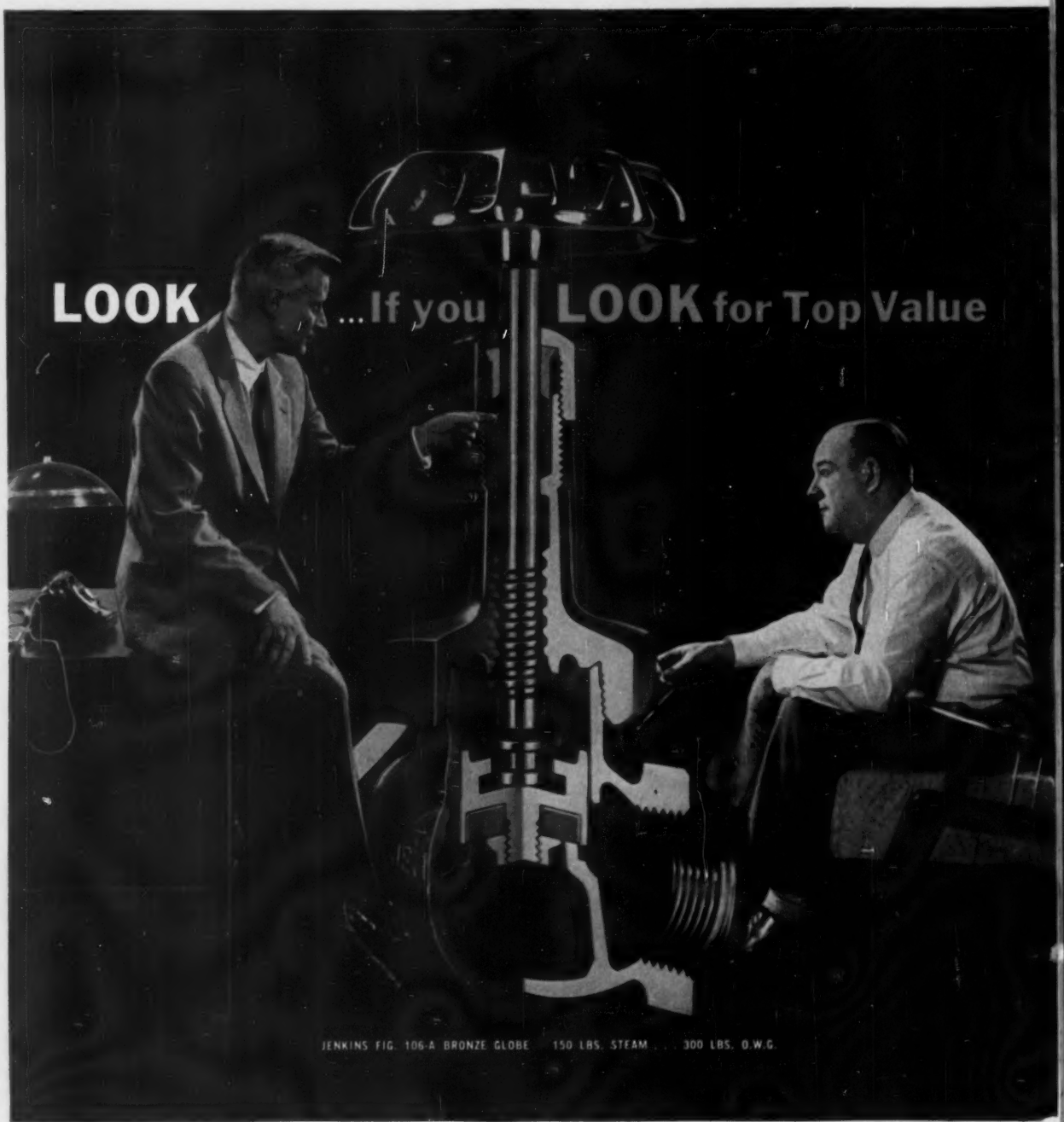
De Laval application engineers will gladly give you more information on steam turbines to suit your specific needs.



DE LAVAL STEAM TURBINE COMPANY

815 NOTTINGHAM WAY, TRENTON 2, NEW JERSEY

DL203



THE FIRST renewable composition disc valve was a Jenkins Valve, originated nearly a century ago. Compare today's Fig. 106-A Bronze Globe with any other. See why so many valve users agree that a *Jenkins* is still the FIRST for top value. For descriptive folder No. 189-B on the full line of Jenkins Bronze Globe, Angle and Check Valves write to Jenkins Bros., 100 Park Avenue, New York 17.

Sold Through Leading Distributors Everywhere

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES

in DISC EQUIPPED BRONZE VALVES

LOOK at that Wheel — Tough malleable iron. Design unequalled for cool, sure grip.

LOOK at the Index Plate — Has Fig. No. etched in green background. Held by wheel nut.

LOOK at the Wheel Nut — Secured by rolled-over spindle end. A quality detail.

LOOK at that Spindle — Made of high tensile bronze. See how much heavier it is . . . how many more deeply cut threads engage bonnet. And, the crowned head that reduces friction on disc holder. Sure, it costs more to make a spindle this way. But it reduces wear, preserves packing, means easier operation.

LOOK at the Packing Nut and Gland — Note the heavy and deep bronze hex. And, that bronze gland designed to compress packing toward spindle.

LOOK at that Packing Box — Its depth equals 1½ times spindle diameter. More packing space means less repacking. An asbestos, lubricated and graphited packing is used.

LOOK at that Bonnet — One-piece, screw-over design with big hex surfaces is easy to remove. Take an extra look at the bevel joint between bonnet and body, serving as an internal brace against the crushing effect of the bonnet assembly. Millions of Fig. 106-A in use for years prove this unique design licks distortion and springing.

LOOK at the Disc Holder — It's the Slip-on Stay-on type originated by Jenkins. Correct protective depth prevents flaking or cracking of disc.

LOOK at the Disc — Easily renewed without removing valve from line. Made of compositions to suit various services . . . and *made by Jenkins*, the only maker of both valves and discs.

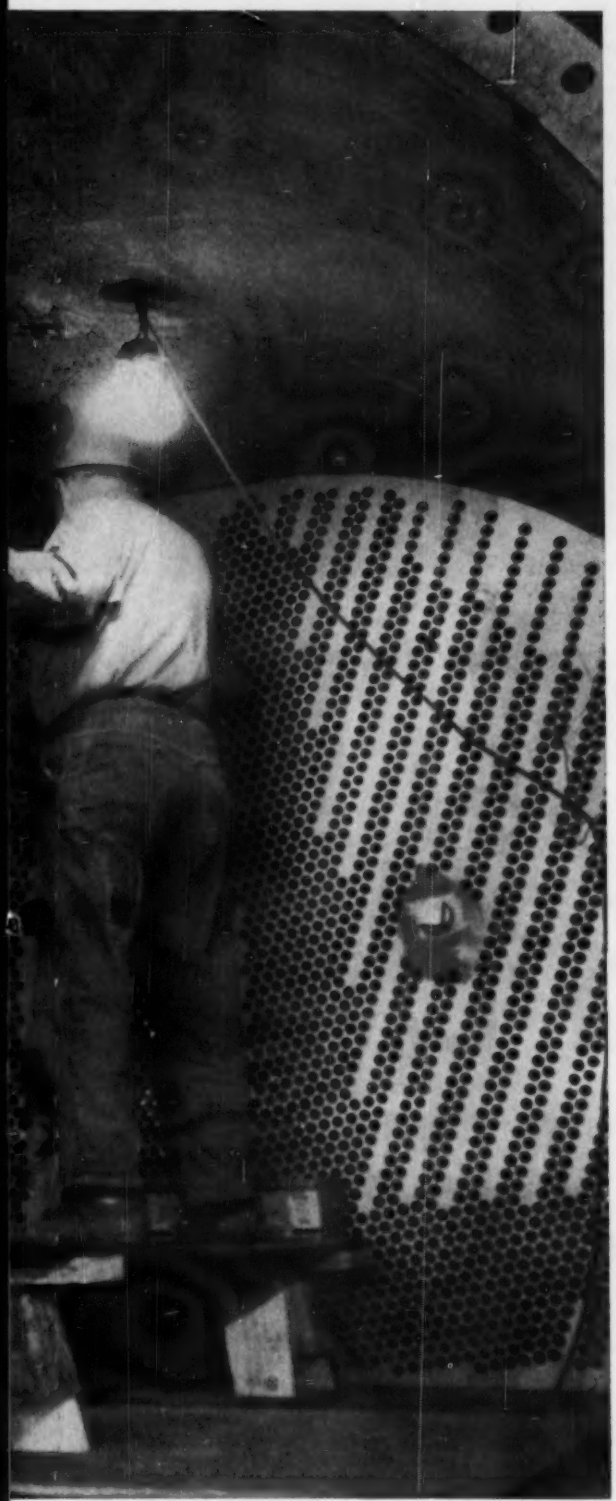
LOOK at that Body — Just compare wall thickness of this high tensile bronze body with any other valve. The factor of safety is many times higher than rating requires. See the curved diaphragm to protect seat from distortion by pipe strain. Note that the raised seat is higher to permit more reseating operations . . . and wider, so it won't cut into disc. Pipe threads are full length and clean cut.

LOOK at this . . . for Throttling — Just replace the disc nut with this Throttling Nut and a Fig. 106-A becomes well-suited to throttling service. This unique nut reduces the effects of wire drawing and its long legs restrict flow for accurate control. Many plants take advantage of this versatile valve to reduce valve and parts inventory.

Don't tube up your condensers without calling Chase®

Unique Chase Condenser Tube Clinic

Provides Complete 8-Point Service



It's just plain common sense to talk to Chase first—before you order tube for original equipment or for retubing. Here's why: The Chase Tube Clinic has a special 8-point program that's ready to serve you in all these ways:

1. **WATER ANALYSIS** – either original or recheck, to help eliminate failure.
2. **TUBE FAILURE ANALYSIS**—by examination of sections of tube, determine why the failure and how to avoid repetition.
3. **CORROSION SERVICE**—predicts where to look for trouble based on the collected experience with water samples and service conditions from hundreds of areas all across the country.
4. **PRODUCT QUALITY CONTROL**—Chase tube meets rigid ASTM specs, and is given special Chase-developed electronic tests as well.
5. **WIDE ALLOY CHOICE**—Chase has the alloy available (brass, copper, aluminum, stainless or bimetal) to meet any combination of service conditions.
6. **STRATEGICALLY-LOCATED STOCKS** and mills can meet normal or emergency delivery schedules.
7. **APPLICATION ADVICE**—Chase tube engineering staff can help with design of tube sheets; welding or rolling-in installations; advice on use of inserts; selection of dual-gauge or thickened end tube, etc.
8. **PACKAGING TO SPECIFICATION**—When you order tube from Chase, it comes fully protected against damage, and in job-designed packaging to meet your exact specifications and installation needs.

Get in touch with the exclusive Chase Tube Clinic today—by calling your nearest Chase Representative, or by checking and mailing the coupon below.

Chase

BRASS & COPPER CO. WATERBURY 20, CONN.

Subsidiary of ***Kennecott Copper Corporation***

CHASE BRASS & COPPER CO.
DEPT. P-12, WATERBURY 20, CONN.

Please send me the following literature:

☐ Condenser Tube ☐ Information on welding installations
☐ U. Bends ☐ Full details on how to take advantage of Chase Tube Clinic Service

NAME_____ TITLE_____

COMPANY NAME_____

STREET ADDRESS_____

CITY_____ ZONE____ STATE_____

(at right) 4,000-90,000 lb/hr – The compact Type VP package boiler is available in a wide range of capacities from 4,000 to 90,000 lb/hr. Shipped ready to install on a simple foundation. Features include: Pressurized firing, water cooling on all four sides, push-button operation, minimum noise and vibration.

C-E SHOP-ASSEMBLED BOILERS: Type VP – Package boiler for the majority of industrial steam needs; **Type PCC**—Controlled circulation. For high output, high temperatures; **Type HCC** – High-temperature-water boiler. For large-scale heating uses; **Type WCC** – Utilizes waste heat from industrial furnaces. Controlled circulation.

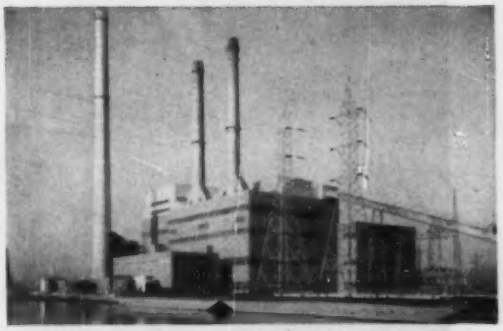
UTILITY-BOILER ENGINEERING GIVES EXTRA DEPENDABILITY

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

...in C-E Package Boilers

To a large extent, a utility company's operating cost is based on the efficiency and dependability of its steam generating equipment. With a major part of its business being with these power companies, C-E has developed a "utility-boiler" engineering philosophy that applies to *all* C-E products, large or small. You can be sure that *your* C-E boiler represents the latest thinking in thermodynamics and boiler design – and that materials and construction meet the most exacting standards. For *extra dependability*, specify "C-E."

Write to C-E for answers to your questions on C-E package and shop-assembled boilers. Catalogs are currently available on types VP, PCC and HCC.



3,900,000 lb/hr – A good example of utility-boiler engineering . . . C-E is currently at work on a new boiler for Commonwealth Edison Company, Chicago, which is the largest boiler ever ordered by an American utility company. The huge unit will serve a 510,000-kw generator and have a rated capacity of 3,900,000 pounds of steam an hour.

COMBUSTION C-E ENGINEERING

General Offices: Windsor, Conn. • New York Offices: 200 Madison Avenue, New York 16, N. Y.

C-2858

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

REDISCOV

Coal operators on the C&O have done a revolutionary job of modernizing, in both mines and preparation plants to economically produce high quality coals. These investments prove coal is the fuel of the future.

ER COAL !

COAL IS VITAL when a firm's survival depends on top efficiency and pared costs

Faced by constantly rising costs, thousands of industrial and commercial plants are exploring every avenue of promising economy in their effort to keep competitive and show a profit.

Many, in their search, have *rediscovered* coal. For today, coal still is the biggest bargain in fuel — more economical, more reliable and convenient than ever before. Highly mechanized mining and preparation methods provide abundant coal of the finest quality, clean and graded for every purpose. Chesapeake and Ohio's huge modern coal-car fleet delivers it dependably, economically. And rich, untapped reserves of bituminous coal stand ready to serve for centuries.

Revolutionary advances in combustion equipment further enhance coal's superiority as a source of heat, power and process steam. New installations or modernization can provide automatic combustion control and complete instrumentation from bin to boiler and beyond.

Coal, for these reasons, remains the wise choice in fuel... for industry... for small businesses and commercial establishments... for institutions. It is the low-cost, high efficiency fuel, and *it's here in abundance!*

Chesapeake and Ohio Railway

TERMINAL TOWER, CLEVELAND 1, OHIO

Outstandability in Transportation

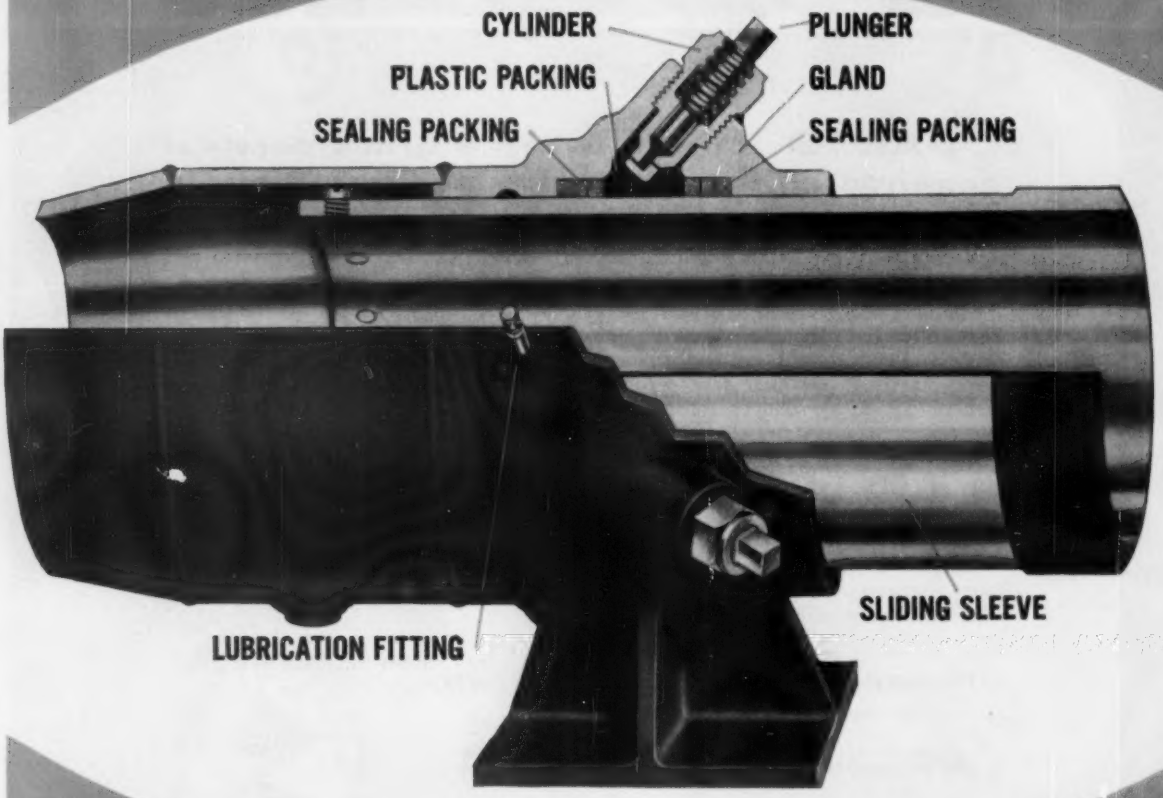
A modern boiler room in pastel colors has a clean, almost clinical appearance. Automatic sealed handling of coal and ash eliminates dust. Advance-design combustion equipment gets top BTU's from your fuel dollar.

C&O Fuel Service Engineers provide free consultation to C&O patrons on combustion, application, equipment, or plant arrangement problems. Write to R. C. Riedinger, General Coal Traffic Manager, above address.

The 5100-mile Chessie Route directly serves over 300 mines in America's richest bituminous coal reservoir with the finest fleet of 68,000 coal cars. Specify C&O routing for dependable, efficient delivery.

CHESSIE SERVES THE COAL BIN OF THE WORLD

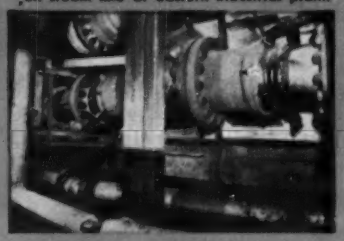
GIVE STEAM and HIGH TEMPERATURE



Only Yarway GUN-PAKT combines these outstanding features with design simplicity. GUN-PAKT Joints are available in single or double ends, welding or flanged, and in standard pipe sizes up to 30".

● 5 of 36 Yarway Gun-Pakt Joints, 2½" to 16" sizes, welding ends on steam lines at mid-west state institution.

● 6" Yarway Gun-Pakt Joint, flanged ends, on steam line at eastern industrial plant.



● Two 10" Yarway Gun-Pakt Joints, flanged ends, on return line of high temperature water system at New Jersey industrial plant.

● Group of 8" Yarway Gun-Pakt Joints, with automatic lubrication, on high temperature water lines at large international airport.

WATER LINES THESE BENEFITS...

✓*TROUBLE-FREE SERVICE*
✓*LOW MAINTENANCE*
✓*SIMPLIFIED DESIGN*

WITH YARWAY GUN-PAKT EXPANSION JOINTS

Only Yarway GUN-PAKT Expansion Joints offer *simplicity*, *efficiency*, and *freedom from the "headaches"* that plague many plant engineers. That's why more engineers are specifying Yarway for efficient operation of steam and high temperature water piping in industrial plants, institutions and universities.

Yarway GUN-PAKT Expansion Joints offer you these advantages:

CONTINUOUS SERVICE—Shutdowns are eliminated. Addition of packing is seldom necessary, but may be added *under full line pressure.* No vents. Never needs repacking. *One plant lost, through forced shutdowns, production valued at $25,000. a day—until joints were replaced with Yarway* GUN-PAKT.

RUGGED DEPENDABILITY — All-steel construction with durable, chromium-plated, seamless steel sleeves. No chance of *metal fatigue.* Wrought steel bases provide rugged, positive anchorage.

INTERNAL AND EXTERNAL GUIDES—Positive alignment of sleeve in stuffing box—*where it counts.*

LIGHT WEIGHT, STREAMLINED DESIGN—Requires less space to install, less space to maintain, smaller manholes, fewer joints needed per length of pipeline.

MINIMUM MAINTENANCE—Many GUN-PAKT Joints have been *in service over 25 years with only nominal maintenance*—no major repairs or periodic overhauls. NEVER A SHUTDOWN FOR REPACKING. Maintenance records show an average of one manhour and 65 cents worth of packing needed per joint per year.

Why don't *you* investigate the advantages of GUN-PAKT Joints now? A Yarway engineer will be glad to discuss the subject with you. Invite him to call. Ask for Yarway Bulletin EJ-1917, too.

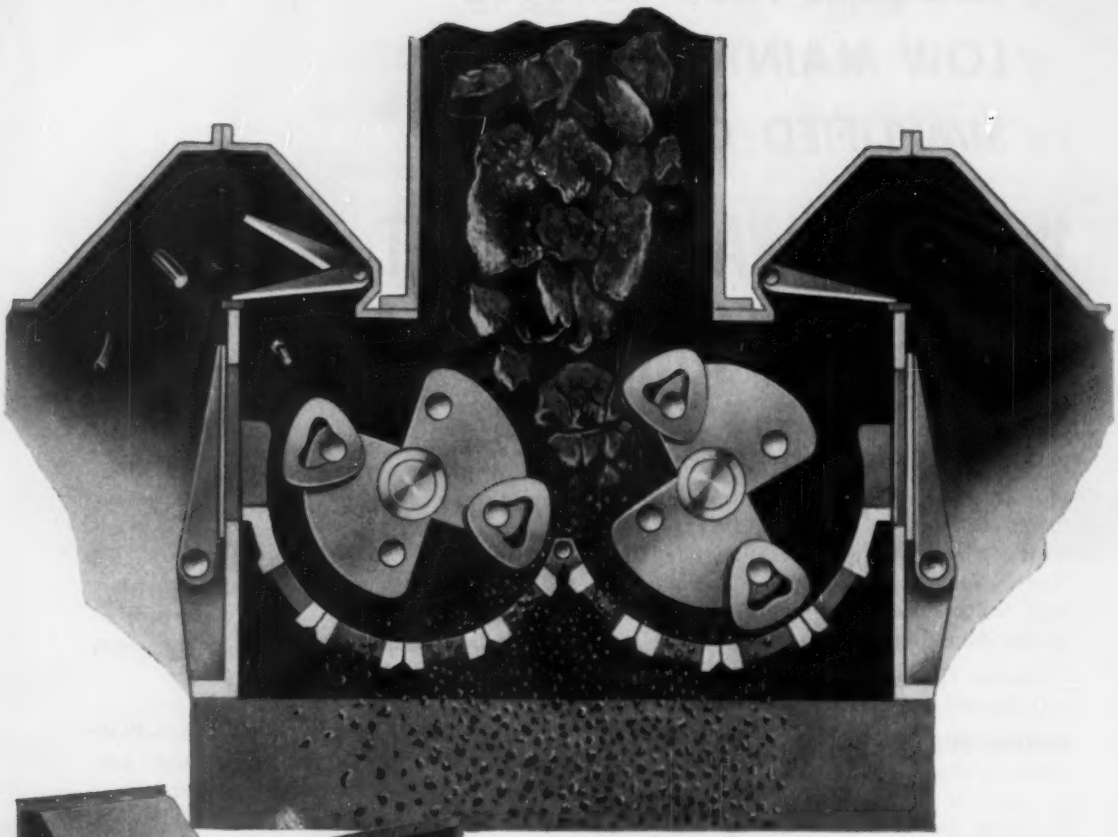
YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

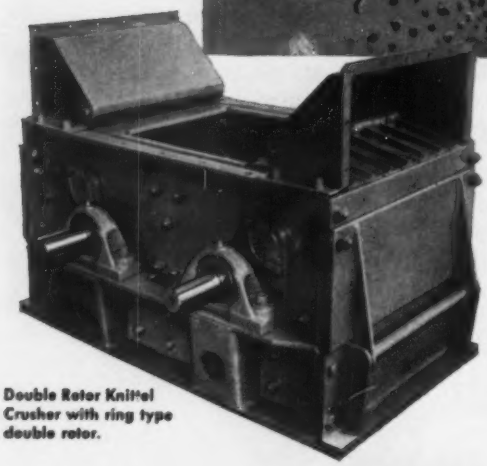
YARWAY

For more facts circle 215 on Reader Service card, p 139

STEPHENS-ADAMSON

KNITTEL CRUSHER Ring Type with Double Rotor





Double Rotor Knittel Crusher with ring type double rotor.

DOUBLE ROTORS BLAST LUMPS TO SIZE WITHOUT DANGER OF PLUGGING

- EXCLUSIVE CRUSHING ACTION . . . Permits the material to fall further into the crusher where two sets of triangular sectors can take a high velocity direct blow on the suspended lumps. Lumps are not only shattered but are literally gobbled up in a continuous flowing stream to the sizing grates.
- CRUSHES DAMP MATERIALS with FULL CAPACITY . . . Eliminates the use of stationary breaker plates, as a result there is no plugging or choking and full capacity is maintained.
- LESS HEADROOM — LESS POWER REQUIRED . . . Requiring considerably less headroom and less power than with single rotor machines.
- TRIANGULAR SECTORS . . . Three wearing surfaces of manganese steel triangular sectors automatically position themselves to present the least worn surface to the crushing action.
- GRATE SIZING BARS . . . Provide accurate sizing of materials, prevent uncrushable materials from passing.
- AUTOMATIC TRAMP IRON RELEASE . . . Steel fingers, operating independently, automatically lift to pass uncrushable material.

WRITE FOR BULLETIN 858

S-A

ENGINEERED BULK HANDLING SYSTEMS

SPEEDWALK® PASSENGER CONVEYORS

SPHERICO® BEARINGS & ROD ENDS

ENGINEERING DIVISION

STEPHENS-ADAMSON MFG. CO.

GENERAL OFFICE & MAIN PLANT, 8 RIDGEWAY AVENUE, AURORA, ILLINOIS

PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA • CLARKSDALE, MISSISSIPPI
BELLEVILLE, ONTARIO

For more facts circle 216 on Reader Service card, p 139

VERY PLEASED were user and contractor with the ease of installation and start-up of "Big Bertha," the 7000-hp Elliott motor shown below. It drives a compressor in the Port Neches plant of Jefferson Chemical Company.

"ready to run" when delivered

means easy, quick, economical installation

Elliott eliminates large motor "bugs" at the factory

A fundamental feature of Elliott motor manufacturing is to make certain that all motors are "clean" when shipped. Careful checks, tests and adjustments at the factory eliminate potential trouble-making "bugs" before shipment, making installation, start-up and early operation smooth and easy.

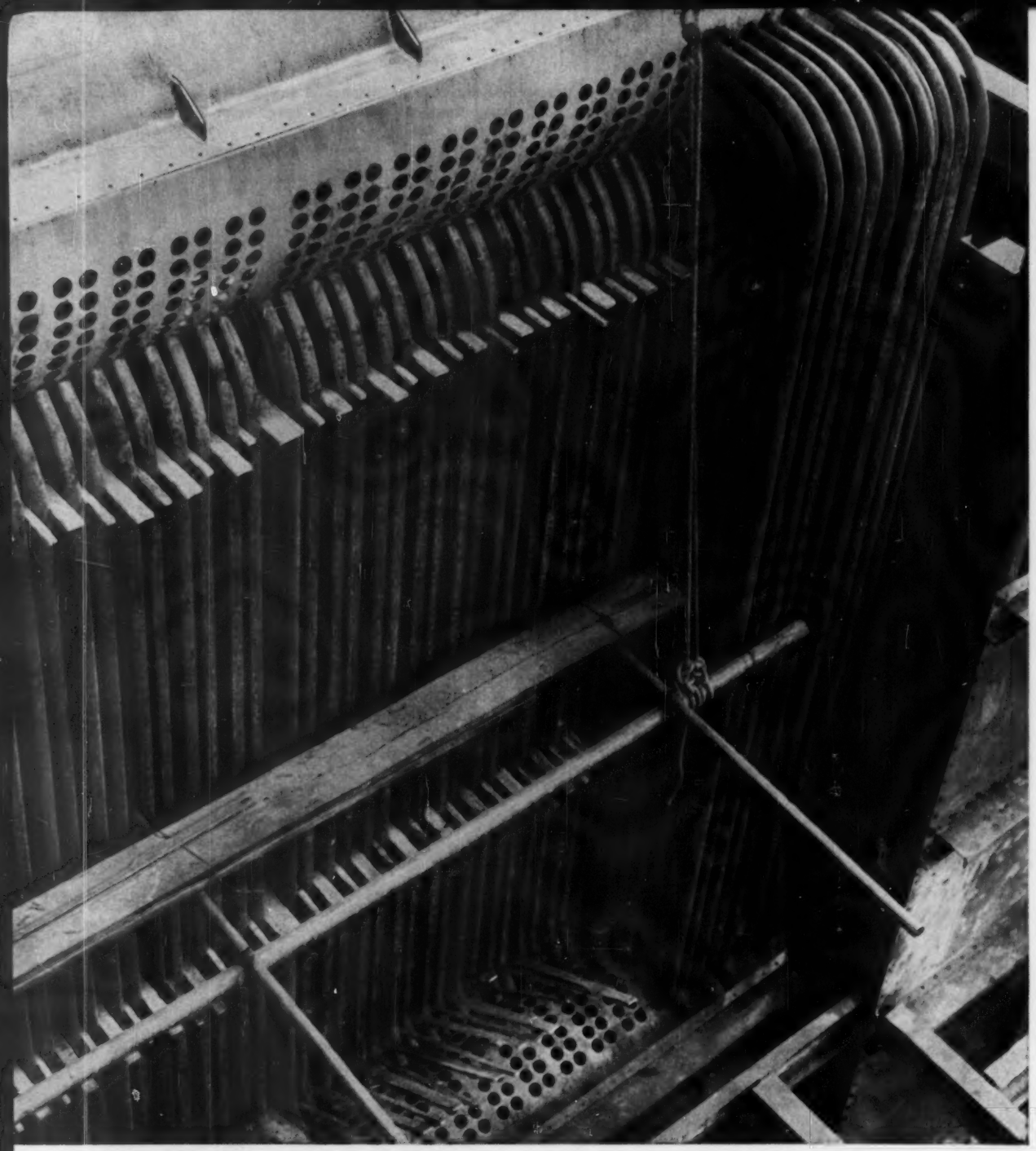
A good example is the 7000-hp Elliott motor shown above, dubbed "Big Bertha" by the operators. It went into operation very, very smoothly, which pleased both contractor and customer. And this is not an isolated case; the Elliott reputation for clean, bug-free motors is very well established. "You can bolt them down and start them up" is what our customers say of Elliott large motors.

Of course, "cleanliness" is only one manifestation of the high quality and perfection of every detail that is characteristic of all Elliott large motors. An interesting sidelight on this particular installation is that the motor was found to be carrying a load considerably in excess of guaranteed rating, without the slightest sign of distress

It is no wonder that experienced users say that the *very finest large motors built are built by Elliott.*

ELLIOTT Company
Ridgway Plant, Ridgway, Pa.

RO-3



Strong, Modern, Dependable

REPUBLIC ELECTRUNITE BOILER TUBES are produced from highest quality flat rolled open-hearth steel and manufactured by Republic's exclusive process that ELECTRically-UNITEs the tube under pressure without additional foreign or extra metal. Each length of ELECTRUNITE is hydrostatically or electronically tested to conform with applicable ASTM specifications, and the ASME Boiler and Pressure Code. ELECTRUNITE is specified for the big jobs because dependability is built-in. The ELECTRUNITE process assures uniform wall thickness, uniform ductility, uniform diameter, and true concentricity. Bends are smooth and uniform. Rolling-in operations are easier.

POWER FOR PAPER MAKING...

with REPUBLIC ELECTRUNITE BOILER TUBES

Continuous, dependable power is one of the first requirements in paper making. That is why Republic ELECTRUNITE Boiler Tubes are on the job in the new boiler plant of the West Virginia Pulp and Paper Company, Covington, Virginia.

Erie City Iron Works, Erie, Pennsylvania, were designers, engineers, and erecters of the unit, producing 77,900 pounds per hour at a normal operating pressure of 170 pounds. Waste black liquor from digestion of pulpwood is burned in a rotary incinerator and the hot gases are fed into the boiler, producing steam, the power for paper making.

ELECTRUNITE is produced by an exclusive process universally accepted by leading technical authorities, code societies, boiler and heat exchanger manufacturers, Federal and State committees, and boiler insurance requirements.

Full normalizing, uniform wall thickness, diameter, true concentricity, assure easy workability and inservice dependability. Bends are smooth, uniform. Rolling-in operations are easier.

To learn how ELECTRUNITE can offer you greater savings in installation time and operating costs, call your Republic Representative. Or write.

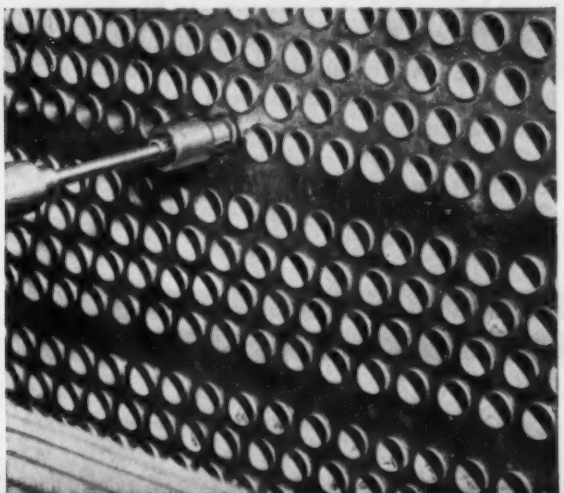
FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor Dimension of Defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	0.006 IN.	0.0025 Square Inches
18	0.006 IN.	0.003 Square Inches
16	12.5% of Wall	0.003 Square Inches
14 and 13	12.5% of Wall	0.004 Square Inches
12 and Heavier	12.5% of Wall	0.005 Square Inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

FARROWTEST—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above, at no extra cost.

REPUBLIC ELECTRUNITE STAINLESS STEEL TUBING resists corrosion and provides long trouble-free service in heat exchanger, condenser, evaporator operations. When water is a problem, call your Republic representative, or send coupon for additional information.



REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. PO-9757R
1441 REPUBLIC BUILDING · CLEVELAND 1, OHIO

Please send more information on the following products:

☐ Republic ELECTRUNITE® Boiler Tubes ☐ FARROWTEST®
☐ Republic ELECTRUNITE Stainless Steel Tubing

Name_____ Title_____

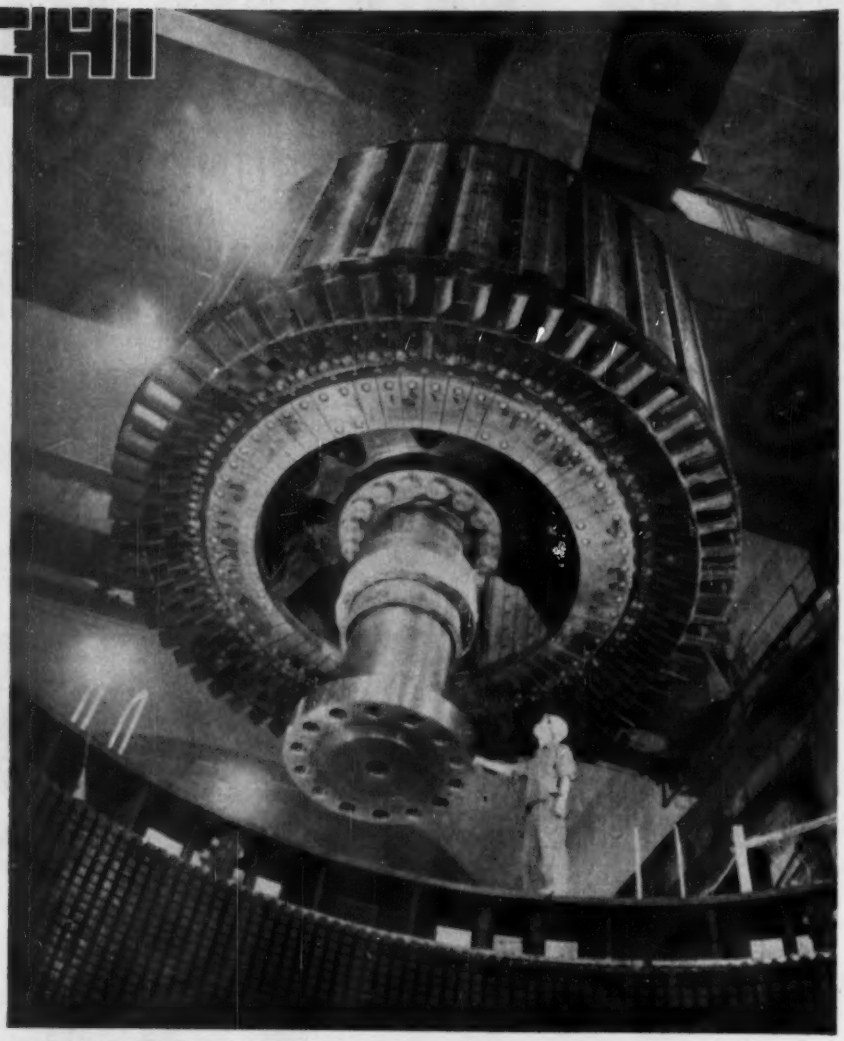
Firm_____

Address_____

City_____ Zone____ State_____

HITACHI

Another Big Hydraulic Turbine and Generator by Hitachi



Hitachi has recently completed two 137,500kw/125,000kVA hydraulic turbines and generators for the Miboro Power Station in Central Japan. The turbine is of the vertical-shaft Francis type, and specified for a speed of 225rpm, a maximum effective head of 200m and 76.6 cu.m/sec. water flow, making it one of the largest units of its kind in the world. Its runner has a maximum diameter of 3.7m and the main shaft a diameter of 95cm. The spiral casing, which was constructed in 13 sections to facilitate transportation to the site, has an inlet diameter of 3.35m and an outer diameter of 11.2m.

The generator presents a high-torsoed appearance having been so designed in consideration of the comparatively high speed. Since the generator was designed for a rated voltage of 16,500 volts and, in this respect, represents the first such attempt in Japan, particular care was taken in the corona-shielding and impulse resistance of the stator winding. The generator is rated at 60 cycles, 225rpm and 0.9 power factor but is also capable of operating at 50 cycles, 187.5rpm and 1.0 power factor.

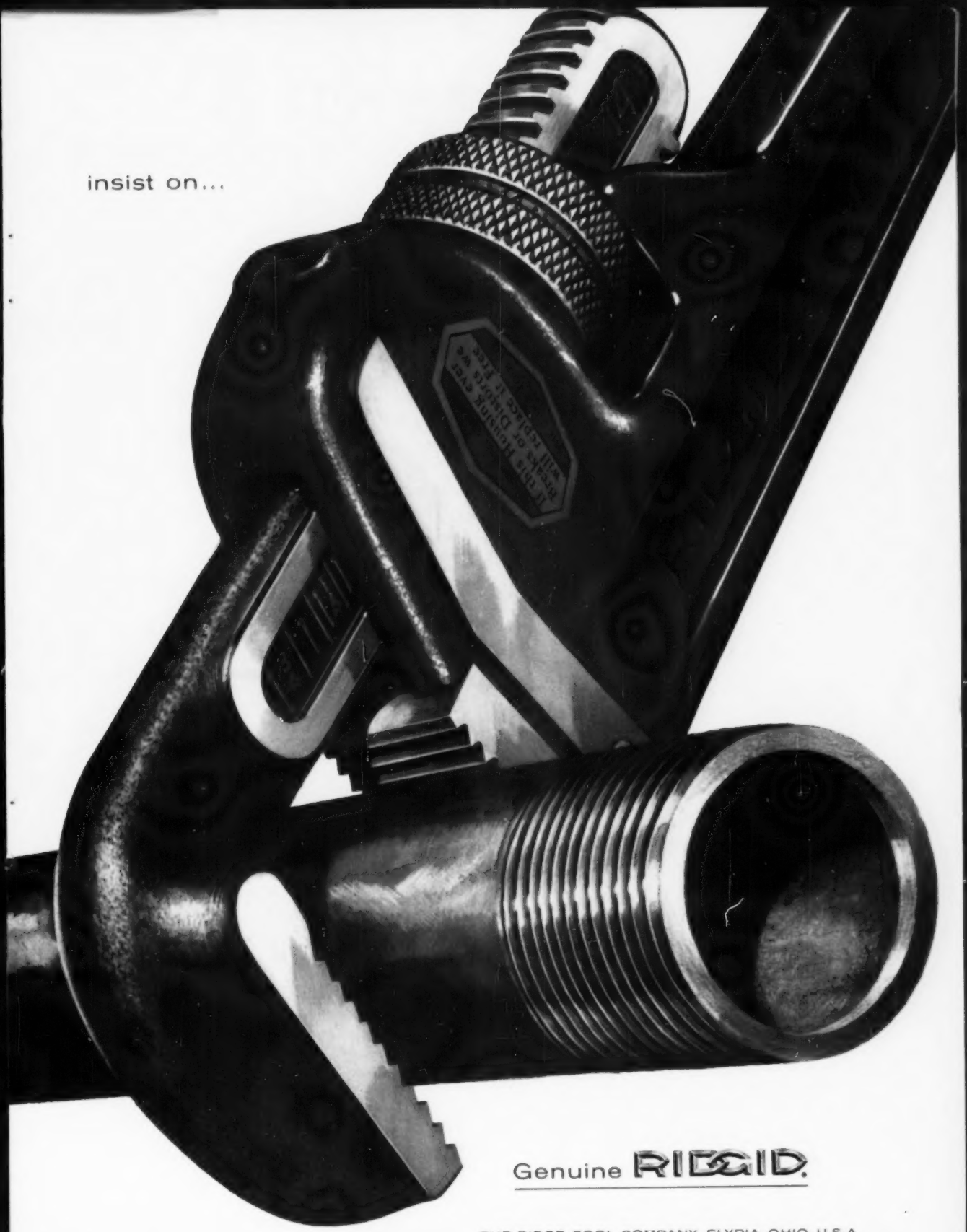
Hitachi, Ltd.
Tokyo Japan

Cable Address: "HITACHY" TOKYO

For more facts circle 219 on Reader Service card, p 139

circle 220 on Reader Service card, p 139 ➤

insist on...

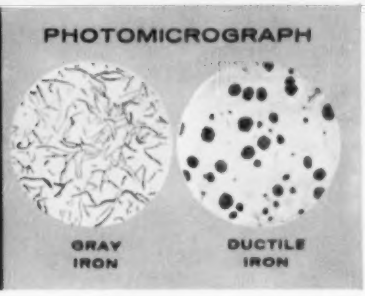


Genuine RIDGID.

THE RIDGE TOOL COMPANY, ELYRIA, OHIO, U.S.A.

PUMPAGE

Goulds news about pumps for process industries



Glassed pump keeps tattletale gray out of light bulbs

Sylvania Electric Products Co. uses an abrasive slurry of hard fine phosphor particles in a xylol solution to coat the inside of its fluorescent tubes.

This slurry has always been hard to handle. It quickly eroded metal pumps which then contaminated and discolored the slurry. Discoloration increased rejects. A pneumatic system was tried . . . it needed constant monitoring and created a vapor hazard.

Sylvania engineers installed a Goulds-Pfaudler test pump, estimating a nine-month life would pay for the pump. *Over two years later*, the pump shows no wear or foreseeable future problems.

Sylvania now has four Goulds-Pfaudler glassed pumps, each running about 80 hours per week and handling 30 gpm of slurry against a 30-ft. head.

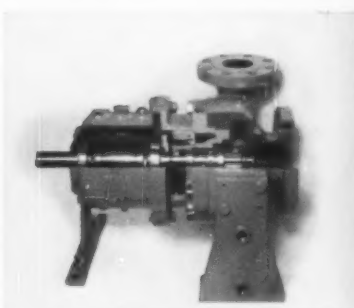
This simple, completely enclosed system ends vapor hazard, involved pipes and controls, and the need for constant monitoring. The inert glass protects product purity.

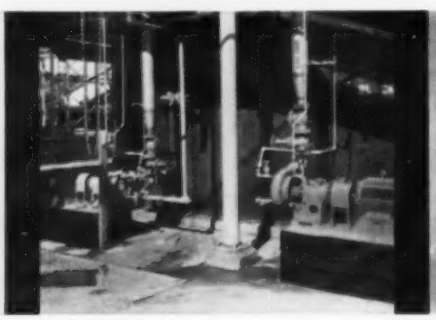
The ductile iron difference

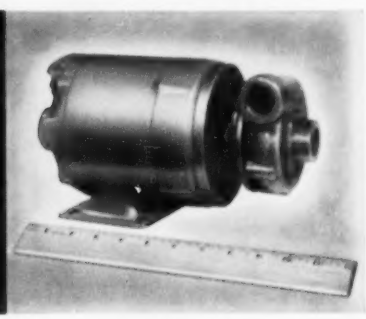
To make ductile iron, magnesium is added to molten cast iron, changing the sharp, thin graphite flakes to spheroids. The spheroids have large areas of iron matrix between them, and since they have no sharp edges, the ductile iron has far greater strength than the original cast iron.

Ductile iron is so tough it can be used in many applications previously requiring cast steel.

It might pay you to look into this. Write us for information on ductile iron pumps or parts.







Pump with cold feet

The Goulds Model 3775, available in steel and any of the stainlesses, handles temperatures to 600° F because of its cooled support, bearing and seal chamber construction.

It is ideal for handling flammable or otherwise dangerous liquids, withstands thermal shock.

For information on this, or other products on this page, write Goulds Pumps, Inc., Dept. PO-120, Seneca Falls, N. Y.

Vicious viscous kept moving

Over 100 Goulds pumps do a wide variety of pumping jobs at Marathon Southern Corporation.

Among them are two tough 3715's. These keep abrasive, viscous black liquor moving. Each handles 200 gpm to a head of 65 ft. Stainless steel 316 construction resists the bite of hot, abrasive liquor.

Choose construction materials best suited for you when you get the Model 3715. Write for Bulletin 725.4 which lists available materials.

Now...circulate with Hastelloy "C"

If you need a small pump in a hurry to circulate or transfer clear corrosives—we can supply it right off the shelf.

Hastelloy* "C," a highly corrosion-resistant nickel-chrome-molybdenum alloy, is now available on our Model 3604. This $\frac{3}{4}$" centrifugal pump with big-pump stamina is built for 'round-the-clock service in chemical process work, pilot plant or laboratory.

Drop us a line and we will send you a bulletin with performance chart and other information.

*Trademark of the Haynes-Stellite Division of Union Carbide Corp.

GOULDS PUMPS

For more facts circle 221 on Reader Service card, p 139

DAILY GRIND ALWAYS UNIFORM with Pennsylvania Reversible Hammermills

Regardless of condition of coal or amount of hammer wear—Pennsylvania Hammermills are noted for producing a highly uniform product day after day.

Basic design and simple adjustments available to the operator on the spot make this possible.

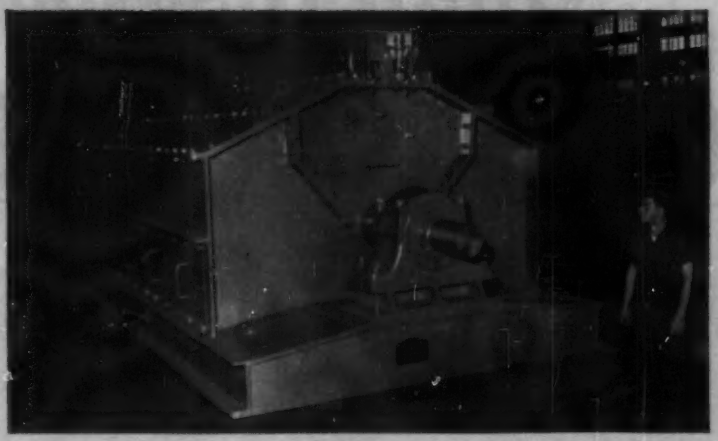
Pin point adjustments of cage-hammer clearance (by ratchet wrench and worm gear assembly) compensate for hammer wear or coal condition.

Crushing action keeps fines to minimum. Free air impact crushing in upper zone prepares coal so there is little dredging of hammers through oversize in cage-bar zone. Results—uniform grinds day after day.

DOUBLE CRUSHING AREA: DOUBLE CAGE, BLOCK AND HAMMER LIFE

No other crushers give you so much more for your money. Pennsylvania Reversible Hammermills give double the crushing area—double the life of cage bars, breaker blocks and hammers. A flick of the switch; rotor is reversed and you are using a duplicate mill.

What's more, hammers need never be hand turned, and wear is kept uniform.



• Pennsylvania Reversible Hammermill for preparing bituminous coal for exact specifications of cyclone burner bin system, ready for shipment to large southern power plant.

With adjustable cage assemblies, hammers can be worn much further while keeping grind uniform—with no falling off of tonnage.

FREE BULLETIN

Bulletin 1040, giving a full description of the design, construction features, operation and maintenance of Pennsylvania Reversible Hammermills, can prove profitable reading for you. Write for a copy today.

PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

DOUBLE DIVIDEND! Pennsylvania Bradford Breaker cleans coal as it crushes

Famous Pennsylvania Bradford Breakers not only crush and size run-of-mine coal—they automatically remove and discharge tramp iron and other refuse. This is just one of many features giving Pennsylvania world leadership for this type of crusher. Over 100 million tons of coal annually are prepared by Pennsylvania Bradfords in power plants everywhere.

For complete information, write and ask for Bulletin 3009.

★ ★ ★

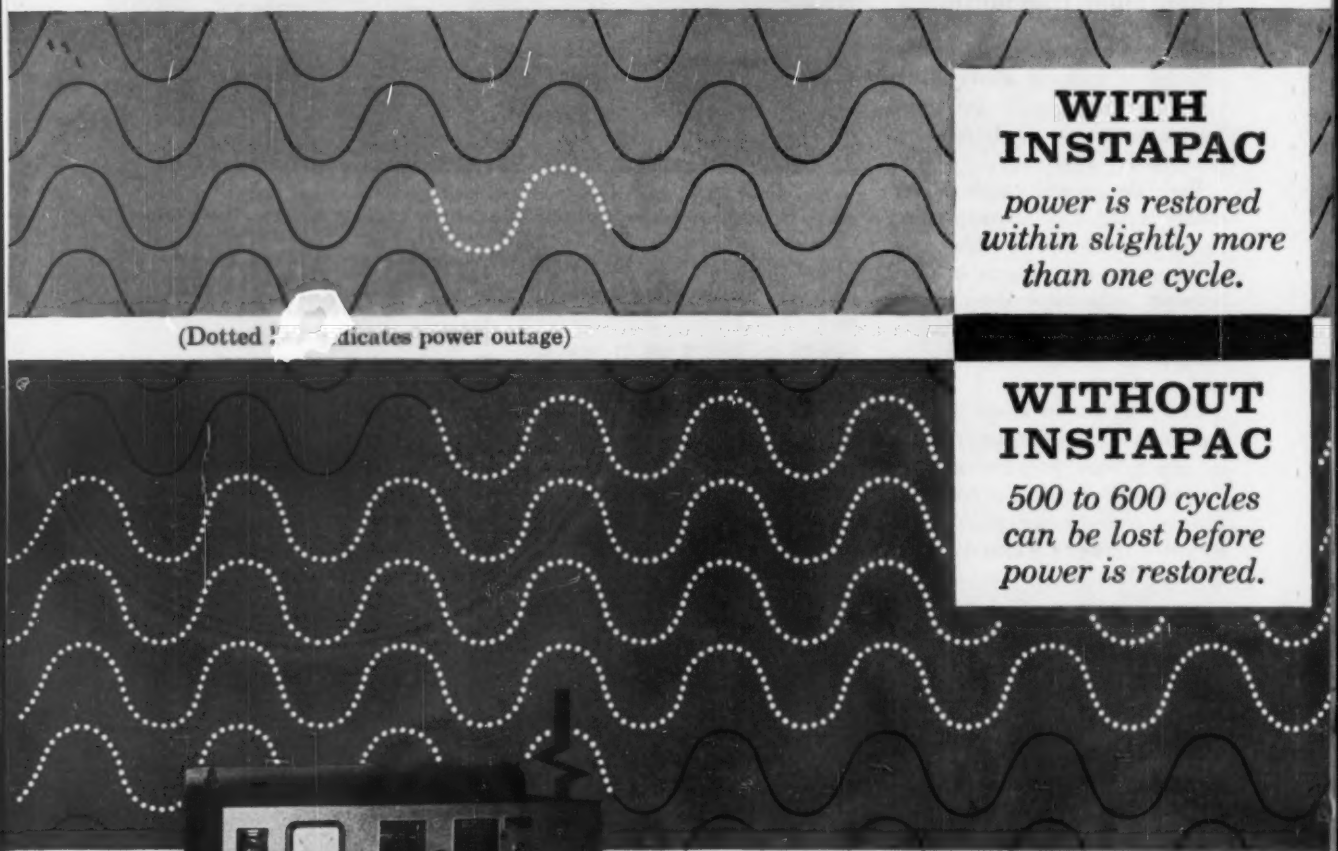
Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT

For more facts circle 222 on Reader Service card, p 139

Onan Instapac provides your equipment won't know


WITH INSTAPAC
power is restored within slightly more than one cycle.
(Dotted line indicates power outage)
WITHOUT INSTAPAC
500 to 600 cycles can be lost before power is restored.

Write for free folder and specifications sheet

Complete data including diagrams showing three popular Instapac hook-ups: (1) Instapac combined with an Onan Standby Power Plant; (2) Instapac with no plant, using batteries for temporary standby power; (3) Instapac as a continuous power source for critical applications where not even the .020 seconds lapse in power can be permitted.

COMPACT SIZE. Wall Mounting: Cabinet (illustrated) 19″ wide, 30″ high, 8½″ deep. Rack Mounting: 19″ wide, 12¼″ high, 8½″ deep.

power so fast that the main power is off

Within 20 milliseconds of a power outage, Instapac supplies emergency power . . . combined with an Onan Electric Plant you have complete standby protection

The seconds it takes to start an engine-driven standby power plant and switch it into the circuit may be too long where continuous operation is essential.

In microwave and television relay stations . . . in marine, railroad and aircraft communications . . . in telemetering . . . etc. . . . a power lapse of only seconds can jumble signals, cause wrong instructions to be sent, cause loss of valuable time, even loss of irreplaceable messages.

If you have any of these situations you need immediate power—you need Instapac.

Instapac is a transistorized inverter which converts battery current to alternating current of the proper frequency and voltage. It is rated at 1 KVA (a booster is available to raise this to 1.35 KVA) . . . 120 volts, 60 cycle; 50 cycle units also available. Instapac may be wall mounted, as illustrated, or rack mounted, to meet your requirements.

Instapac is reliable. There are no moving parts in the inverter itself such as you'll find in a motor-coupled, engine-driven standby plant where there's always the risk the engine won't start fast enough.

Instapac is manufactured by Onan, the world's leading builder of electric power plants—the only electric plants that are Performance Certified to do the job you want done . . . most dependably . . . and at lowest cost.

ONLY ONAN GIVES YOU THIS CERTIFICATION

PERFORMANCE CERTIFIED
We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.
D. W. ONAN & SONS INC.
Minneapolis 14, Minnesota
Onan

Onan®

World's Leading Builder of Electric Power Plants

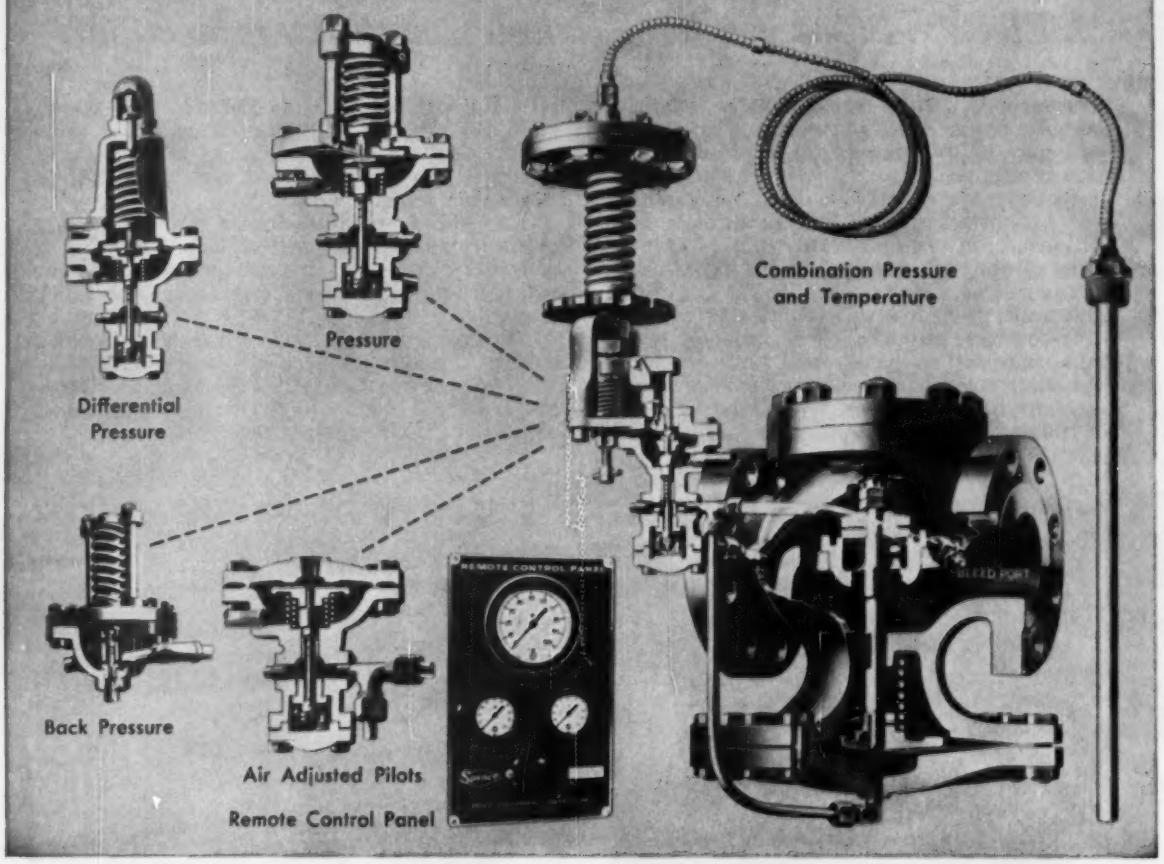
D. W. ONAN & SONS INC., 2668 UNIVERSITY AVE. S.E., MINNEAPOLIS 14, MINN.

For more facts circle 223 on Reader Service card, p 139

(Advertisement)

VALVE TIPS:

All Pilots Fit All Main Valve Sizes Downtime, Maintenance, Inventory Reduced



Let's start off by admitting there's no such thing as a "maintenance-free" regulating valve. Any valve that automatically controls temperatures or pressures within close limits can be affected by dirt in steam lines.

If trouble does develop, engineers want a regulator they can get back on the line — fast. That's one reason why more engineers are standardizing on Spence Regulating Valves with externally mounted pilots. The simple test of disconnecting the external bends establishes whether the trouble is in the main valve or the pilot.

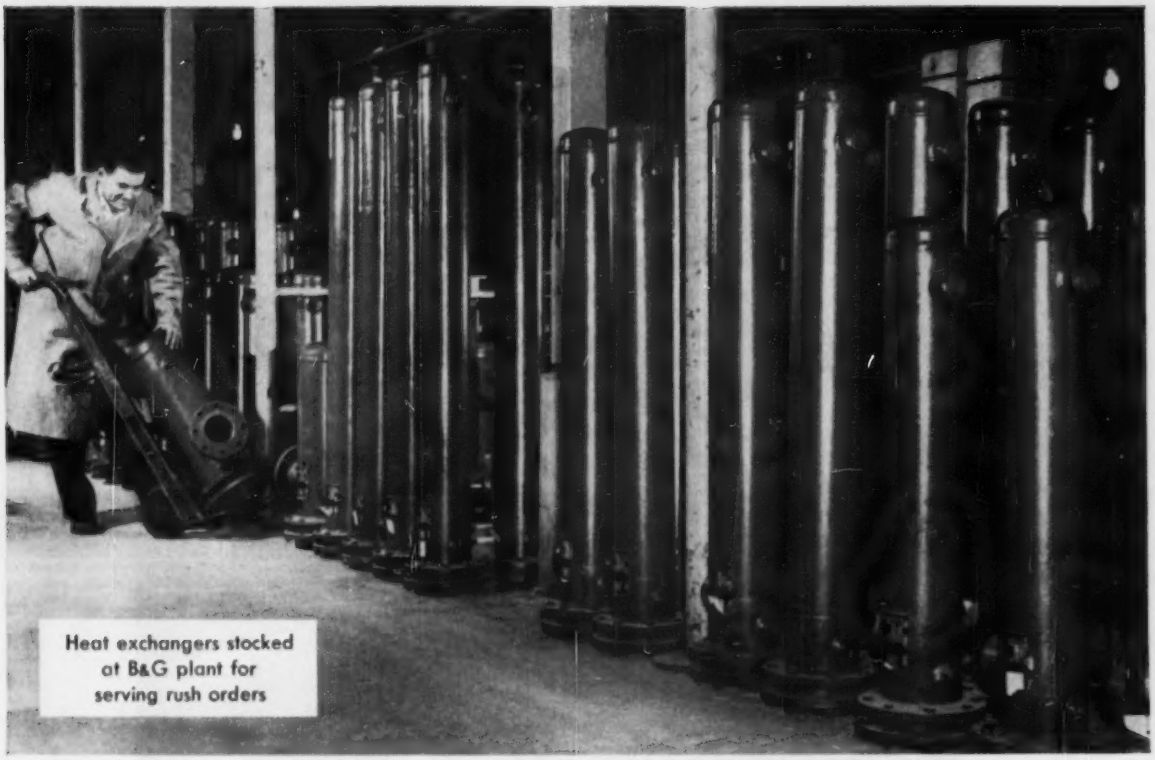
If the main valve is the trouble spot, it can be maintained without removing the valve body from the line. If the pilot is the trouble spot, it is easily removed for cleaning. However, if production downtime is a strong factor, the fastest method is to install a spare pilot and it is inexpensive.

All Spence pilots fit all sizes of Spence main valves. If you have twenty pressure regulators, for instance, all you need is *one spare pilot*. It will fit all main valve sizes from ¼" to 12".

Another advantage of the Spence design is the external pilot is interchangeable. You can change the function of a regulator by merely changing the pilot. In many plants this can represent an important factor in reduced inventory costs because you only carry a few inexpensive extra pilots instead of complete regulators. Obviously, there is also a considerable savings in labor costs when a valve can be converted, in the line, from a temperature regulator to any one of various pressure regulators.

The pictures above show a few of Spence's wide line of automatic regulators. For more information write for Bulletin TE.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York



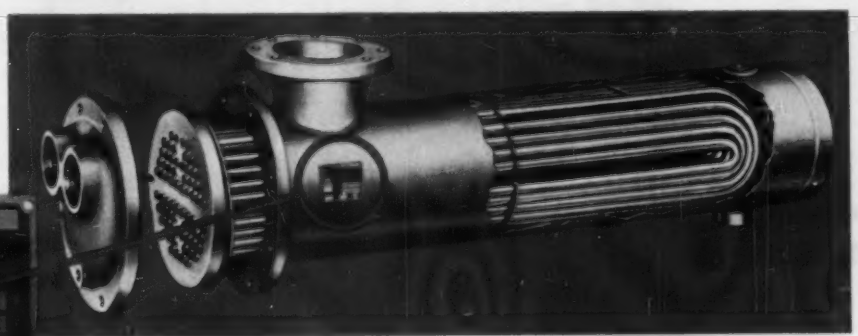
Heat exchangers stocked at B&G plant for serving rush orders

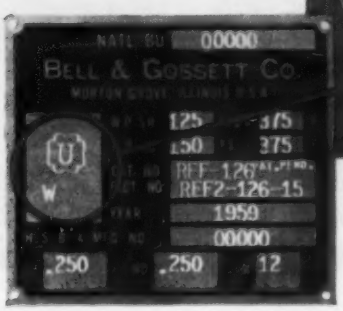
NEED A HEAT EXCHANGER IN A HURRY?

All facilities for heat exchanger manufacture are available under one roof at the B&G plant, where assembly line procedures permit building an inventory of stock parts and complete units. B&G Heat Exchangers are not only engineered to top efficiency but are constructed to the highest standards of quality and safety as required by the A.S.M.E. Unfired Pressure Vessel Code. Form U-1 Manufacturers' Data Report for Unfired Pressure Vessels is furnished with each unit as required by the provisions of the A.S.M.E. Code.

B&G Heat Exchangers are made in both U-bend and straight tube, floating tube sheet models. A comprehensive stock of U-bend exchangers is available for fast shipment. Refrigeration condensers, evaporators, liquid receivers and suction line heat exchangers are also maintained in factory stock.

Send for brochure "The A.S.M.E. Story"



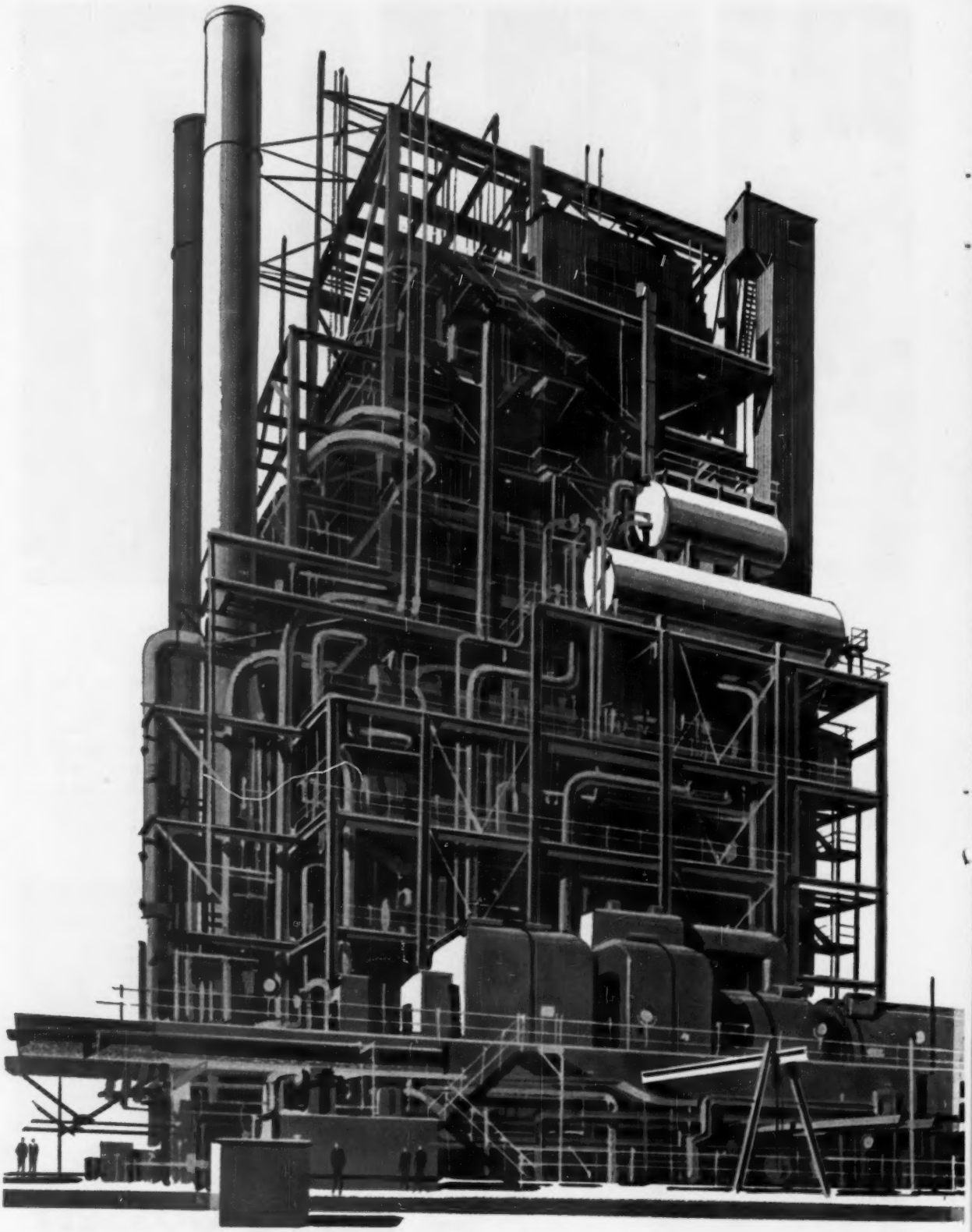


All B&G Heat Exchangers are stamped with A.S.M.E. "U" Symbol

BELL & GOSSETT
COMPANY
Dept. GI-36, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto 16, Ontario

For more facts circle 225 on Reader Service card, p 139



POWER PLANT PRODUCTS HEAT ENGINEERED BY FOSTER WHEELER:

Central Station and Industrial Steam Generators • Steam Condensers and Pumps • Cooling Towers
Pulverized Fuel Systems • Feedwater Heaters • Packaged Steam Generators • Nuclear Components

Why two (or more) heads are better than one

Janus, it is said, could look two ways at once.

If a manufacturer of power plant equipment had only one product to sell, of necessity his view would be limited.

Foster Wheeler has the advantage of being able to see the whole power plant picture because FW designs and builds not only complete steam generators, but also steam condensers, feedwater heaters, evaporators, cooling towers, pulverized fuel systems and nuclear components.

What does this mean to you? It means a better overall understanding of your equipment needs. More smoothly integrated power components. A greater power value for your money.

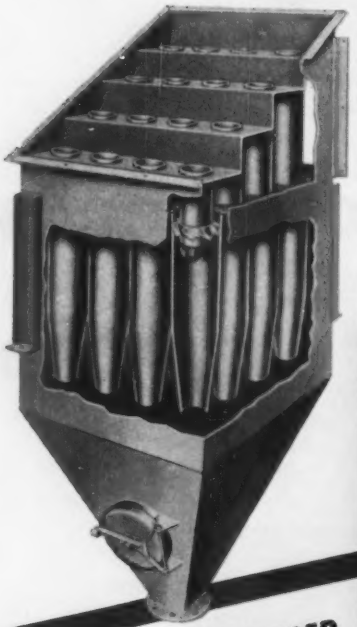
Profit from better designed, better built power plant equipment. Discuss your requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

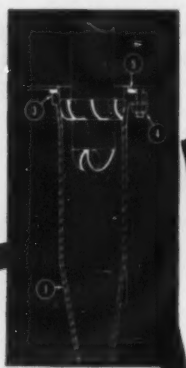
For more facts circle 226 on Reader Service card, p 139

13 BIG REASONS WHY MULTICLONE FLY ASH COLLECTORS



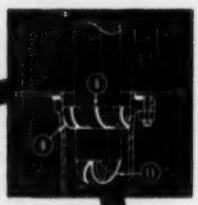
✔ COST LESS TO MAINTAIN...
✔ ARE FAR SIMPLER TO SERVICE!

When you buy fly ash collection equipment, don't stop with a comparison of *initial* cost only. Compare also the cost and simplicity of keeping your collector at top-notch efficiency *throughout the years.* To the outstanding advantages of Multiclone's unique operating features, add the low cost and easy maintenance of this equipment and you'll see why Multiclones are the leading choice wherever *centrifugal* types of fly ash collectors are the most practical solution.



EASILY INSTALLED COLLECTING TUBES

1. **CAST IRON TUBES** assure long wear!
2. **SPECIAL ALLOY TUBES** (FBA Inco #40, Chromehard and Ni-Hard) can be supplied where high temperatures or severe erosion are problems!
3. **TUBES ARE PRECISION-CAST** for exact fit into tube sheet. Tube lip protects sealing gasket!
4. **TIGHT LEAKPROOF FIT** of each tube is maintained indefinitely by special lock nuts!
5. **GAS-TIGHT JOINT** between tube sheet and each tube is assured by special gasket. Joint can be easily renewed when replacing tube!



PRECISION CAST VANES!

6. **CAST IRON VANES** resist erosion!
7. **SPECIAL ALLOY VANES** (FBA Inco #40, Chromehard and Ni-Hard) can be supplied where high temperatures or severe erosion are problems!
8. **VANES ARE EASILY INSTALLED** by simply dropping new ones into place when changing collecting tubes!
9. **EXACT FIT OF EACH VANE** in the tapered collecting tube prevents erosive "blow-by"!
10. **CAPACITY AND EFFICIENCY** of the unit can be quickly altered by simply changing vanes. Assures easy adaptability to new operating requirements — big savings in plant modernization programs!
11. **SPIROVANES** (energy recovery devices) may easily be added to outlet tubes of existing installations to increase capacity or reduce pressure drop!

Plus These Important Advantages...

12. **CUBIC SHAPE** of Multiclone is easier to install and insulate — and requires only ONE simple inlet and outlet duct!
13. **BACKED BY OVER 3300 INSTALLATIONS** serving a wide cross-section of industry, each Multiclone benefits from the unequalled "know-how" gained during Western Precipitation's half-century of leadership in the highly-technical field of modern fly ash collection!

Compare the above advantages with any competitive equipment and you'll readily see why Multiclones are the logical choice for *your particular* operations, too. There's a Multiclone representative near you who will gladly supply further details to fit your individual requirements. No obligation, of course!

Send for descriptive literature on Multiclone equipment.

WP

WESTERN
PRECIPITATION
DIVISION OF JOY MANUFACTURING COMPANY

1000 WEST 9TH STREET, LOS ANGELES 54, CALIFORNIA
NEW YORK 17 • CHICAGO 2 • PITTSBURGH 2 • ATLANTA 5 • SAN FRANCISCO 4
IN CANADA: 8285 MOUNTAIN SIGHTS AVENUE, MONTREAL, P. Q.

Cottrell Precipitators

Multiclone Dust Collectors

Therm-O-Flex Hi-Temp Filters

Dualaire Reverse-Jet Filters

Turbulaire-Doyle Scrubbers

Joy Microdyne Scrubbers

Combination Units

Holo-Flite Processors

Hi-Turbiant Heaters

For more facts circle 227 on Reader Service card, p 139

Completely integrated SOHIO Toledo Refinery

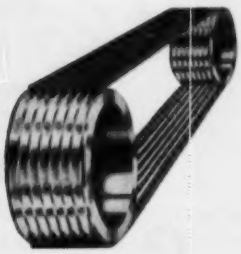
Swagelok®
TUBE FITTINGS

SOHIO Selected SWAGELOK Tube Fittings for just one reason — MAXIMUM RELIABILITY. This Toledo Unit refines 60,000 bbls. of crude oil per day in ONE CONTINUOUS OPERATION. Just consider the absolute necessity for leakproof tube fittings within this installation. No room for failure here! A highly successful example of total integration, Standard Oil Company of Ohio's Toledo Refinery is a functioning tribute to engineering skill and mechanical performance.

FOR MAXIMUM RELIABILITY SPECIFY Swagelok Tube Fittings

Crawford Fitting Company • 884 East 140th Street • Cleveland 10, Ohio • Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

For more facts circle 228 on Reader Service card, p 139



- NO MATCHING PROBLEMS
- MAINTAINS GROOVE SHAPE
- COMPLETE CONTACT-PRESSURE
- CONSTANT PITCH AND SPEED RATIOS
- LESS MAINTENANCE—LESS TAKE-UPS
- LESS BELT AND SHEAVE WEAR

Write for Bulletin M141

R/M POLY-V® DRIVE

MORE POWER...*in Less Space* WITH MORE RELIABILITY

Designed for high volume forgings, this giant 2500 ton automated press developed by Erie Foundry Company is powered by a 250 HP Poly-V Drive. This new drive provides much higher horsepower capacity . . . delivers more dependable power per inch of drive width than ever before possible! Poly-V features a single unit V-ribbed belt across full width of the drive sheave—not an assembly of V-belts. Single unit belt design eliminates length matching problems — minimizes equipment down-time and belt replacement costs, runs cooler, smoother.

Just two cross sections of Poly-V Belt meet every heavy duty power transmission requirement. Ask your R/M Distributor for details about R/M Poly-V* Drive.

*Patented

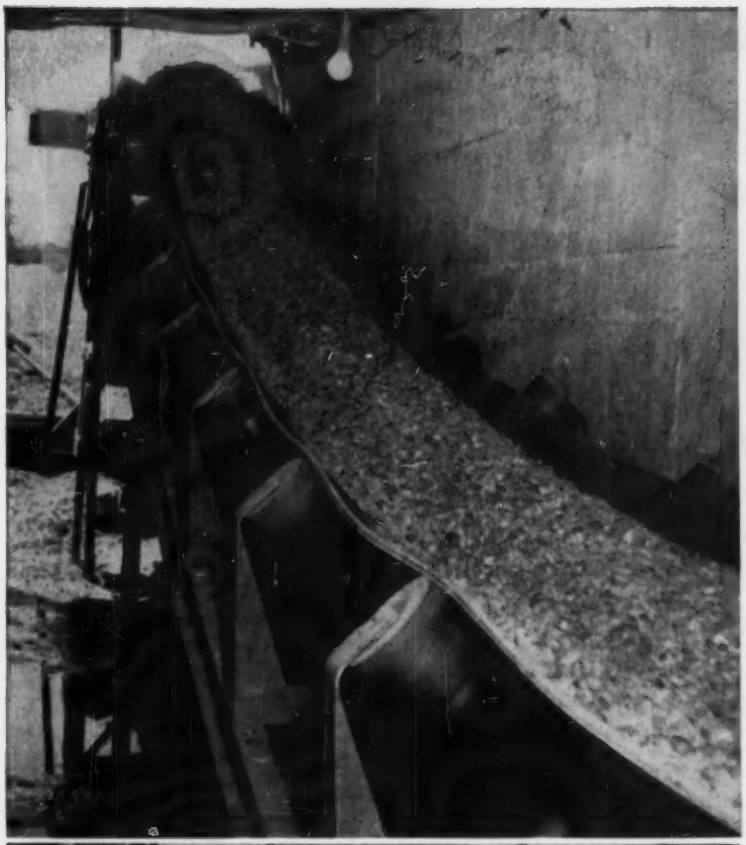
WHEN YOU CHANGE DRIVES . . .
CONVERT TO POLY-V AND BE SURE!

RM1030

RAYBESTOS-MANHATTAN, INC.
MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY

R/M

ENGINEERED RUBBER PRODUCTS . . . "MORE USE PER DOLLAR"

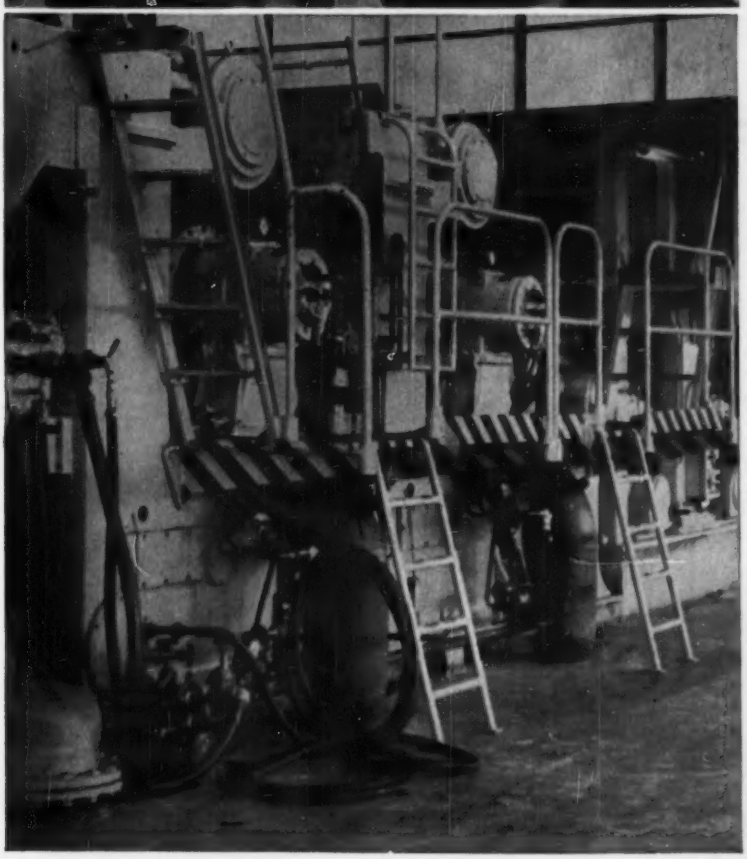


RAY-MAN CONVEYOR BELT

Engineered for 45° Idlers

- TRAINS NATURALLY
- TROUGHS DEEPLY
- HOLDS FASTENERS
- RESISTS IMPACT AND RIPPING
- REQUIRES NO BREAKER PLY
- DOUBLE COMPENSATION RELIEVES OUTER PLY STRESS
- EXCLUSIVE "XDC" LONG-WEAR COVER

Every component of a Ray-Man Conveyor Belt is *precision proportioned* to give you a balanced belt construction, with as much as ⅓ longer life expectancy. It's the same as getting ⅓ more conveyor belt for your money. Further savings are possible, if you use 45° Idlers. Properly engineered, you can haul a fuller load, or install a narrower conveyor. Ray-Man is guaranteed against ply or cover separation at the hinge line where the 45° angle proves too sharp for regular belt constructions. Write for Bulletin M303.



HOMOFLEX HOSE

more flexible, weighs less than any hose for equal pressure

- SUPER-STRONG
- PRECISION BUILT
- NO PRE-SET TWIST—WILL NOT KINK
- INSEPARABLE TUBE-TO-COVER BOND
- UNIFORM INSIDE AND OUTSIDE DIAMETERS
- EASIER, SAFER COUPLING

Strong, lightweight, and "flexible as a rope"—Homoflex is the easiest handling hose and lasts longer. Made in types for air, water, other fluids and gases. Ask about other types of R/M rubber hose for your job applications. Write for Bulletins M620 and M694.

RUGGED ZEBRA

NEW

the multi-layer pipe insulation that goes on fast!

There's nothing dainty about new "K&M" Zebra. Its rugged, full body lets you work fast . . . almost forget about handling breakage. And once it's in place, this low, medium and high-temperature thermal insulation stands up to intense vibration—won't crack or warp from shock or heat . . . as proved in tests by K&M and independent testing laboratories.

Another Zebra advantage is this: it's made in half sections exclusively . . . even for the larger pipe sections. The result is speedier application with fewer joints. Zebra is also relatively lightweight . . . easy to cut and fabricate. It can be re-used . . . dismantled and re-applied. No skin abrasion or cuts either. Zebra has a smooth surface.

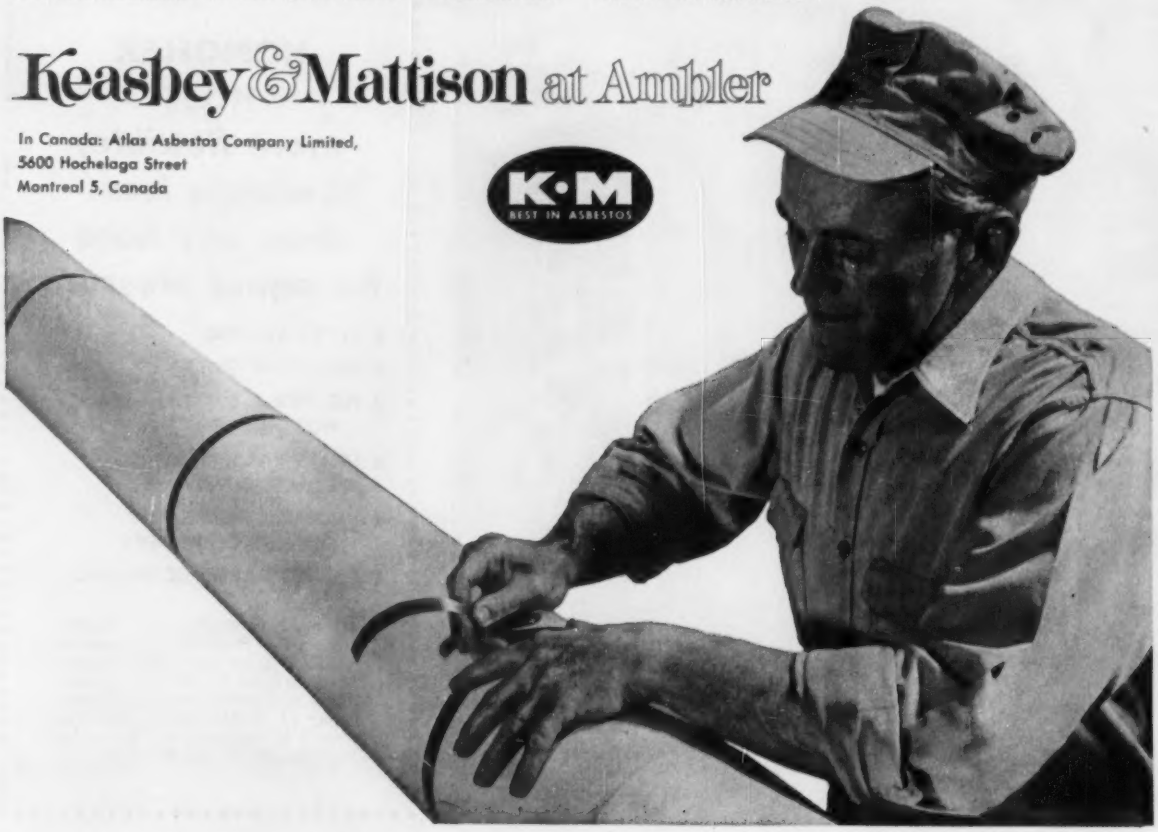
Write today for more information and a free sample of "K&M" Zebra—the rugged new pipe insulation that's fast to apply. Keasbey & Mattison Company, Ambler, Pa. Dept. I-1120.

• for temperatures of 200° F to 1200° F • made of calcium silicate-asbestos fiber bonded felts • meets requirements for density, conductivity, modulus of rupture, and resistance to soaking heat • available in a wide range of sizes and thicknesses.

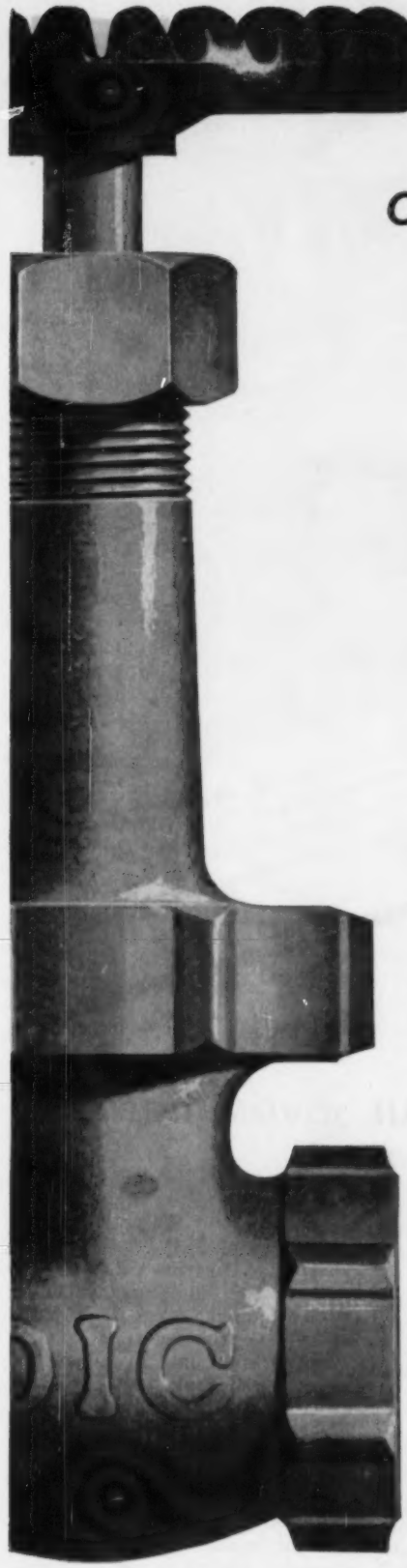
Keasbey & Mattison at Ambler

In Canada: Atlas Asbestos Company Limited,
5600 Hochelaga Street
Montreal 5, Canada

K·M
BEST IN ASBESTOS



For more facts circle 230 on Reader Service card, p 139



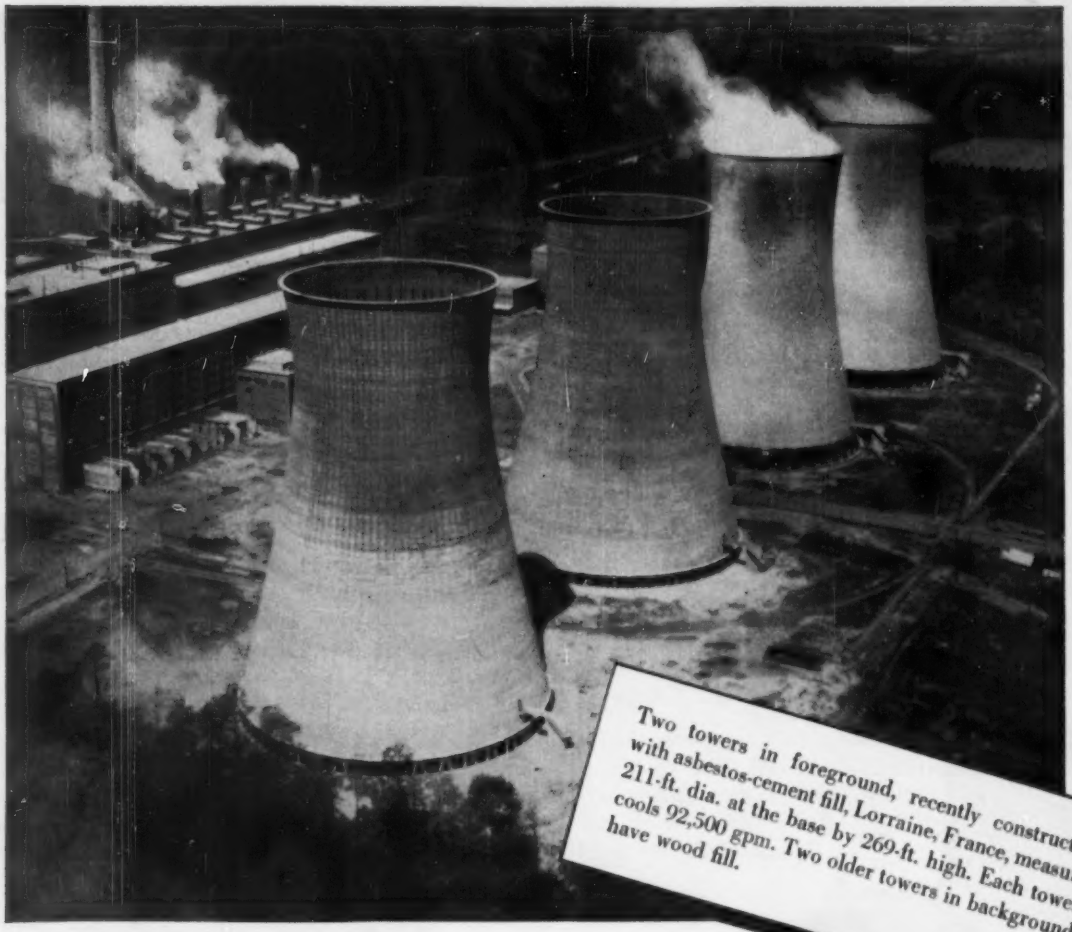
CHECK OIC FIRST...IT PAYS!

SERVICE to meet your valve needs is the "specialty of the house" at your nearby OIC Valve Distributor. As a first-line distributor, he gets OIC's all-out support to insure that you get the service you deserve. OIC's strategically located warehouses, and complete-line factory inventory "backstop" every OIC distributor with a multi-million dollar stock of bronze, iron, ductile iron, cast and forged steel valves. As a result of this strong distributor support, immediate delivery of the more popular items out of distributor's stock is common, and 4 to 5-day delivery out of warehouse or factory stock is routine. When quality is a problem, or delivery is urgent, phone your OIC distributor. Service is his business, and ours.

OIC VALVES | FORGED AND CAST STEEL, BRONZE, IRON AND DUCTILE IRON VALVES

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

For more facts circle 231 on Reader Service card, p 139



Two towers in foreground, recently constructed with asbestos-cement fill, Lorraine, France, measure 211-ft. dia. at the base by 269-ft. high. Each tower cools 92,500 gpm. Two older towers in background have wood fill.

For the greatest return on your investment in cooling towers—

- **longer life — more than 40 years**
- **no need for critical water treatment**
- **virtually no maintenance cost**

HAMON recommends asbestos-cement fill

To learn why a builder experienced with both wood and asbestos-cement fill makes this recommendation, read the accompanying discussion of cost factors

Importance of cooling towers in the planning of tomorrow's steam-electric stations and industrial installations gives point to the design step pictured above—the evolution from wood to asbestos-cement fill. After long experience with both, the large interconnected electric system comprising EDF, the French power authority, and the nationalized French coal mines, has practically standardized on asbestos-cement fill.

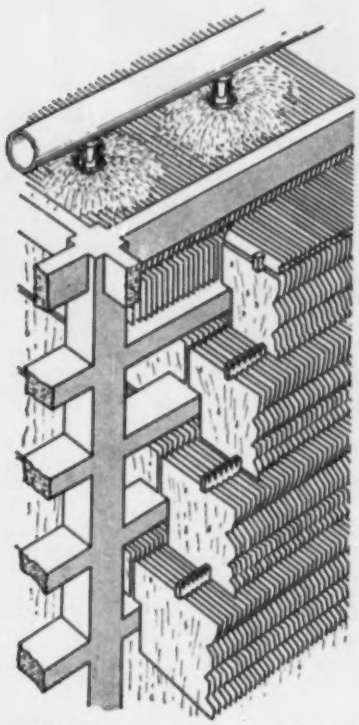
Hamon and other builders supply wood or durable-material towers. The reasoning leading to our preference for durable materials can be shown by analysis of comparative data.

The excellent independent U.S. sur-

veys referred to below deal mainly with wood towers. They cover many years, during which decisions to modify water treatment or to treat wood fill introduced some improvement in the comparative picture. It will take time to fully evaluate this progress.

Water and Wood Treatment

Cooling Tower Institute Bulletin WMS 104 (June 1959) covers studies on 103 towers, and 745 inserted test panels, over a period of more than 7 years. Included are towers in the power field, chemical and rubber plants, and petroleum refineries. Protective treatments applied to test panels were: creosote, acid copper chromate, chromated copper arsenate, ammoniacal copper arsenite. The report concludes: "Water treatment is the most effective means for controlling chemical surface and biological surface attack, whereas biological internal attack can best be prevented by pressure preservative impregnation."



WATER FILM is formed on thin asbestos-cement sheets to give surface for cooling

In the same CTI bulletin, page 4 carries a 52-tower sample indicating that about two-thirds of the deterioration causes are chemical and biological surface attacks against which preservatives cited are not effective.

Close scrutiny of these page 4 figures shows fill life for the 52 towers ranging from 3 years (likely in the Gulf Coast area) to 19 years, with the possibility of a few more years in a couple of cases. For all 52 tower fills, one can evaluate an average life of 12.5 years if one gives a 19-year life to fills not yet replaced on completion of tests. This 12.5-year life reflects the earlier noted fact that many of the towers received the benefit of improved water and/or wood treatment during the test period.

Life Expectancy of Wood Towers

In addition to fill data, page 4 of the CTI bulletin gives figures for walls and frames ranging from 7 to 23 years. One can evaluate a weighted average life of approximately 16 years for walls and 18 years for frames assuming a 23-yr life for those not replaced at end of tests.

A main objective of Hamon and other builders has been to improve these life expectancies. This is not easy because, as page 4 of the CTI bulletin says: ". . . the subject of wood deterioration under cooling-tower conditions is far from completely understood."

As CTI said in 1959: "Water treatment is the most effective means of controlling chemical surface and biological surface attacks". This means pH between 6 and 7. Algaecides, if needed, should not cause oxidation in water circuits. Chlorination should be used only if impossible to do otherwise.

Application of water treatment requires great care to achieve desired results of prolonging wood life without impairing metal parts of tower and associated equipment. Certainly, operations would be simplified and cost reduced if such complex treatment could be avoided by use of less sensitive tower material.

Maintenance and Repair Cost

The most recent paper as far as we know is ASME No. 56-A-59, which covers maintenance and repairs on 50 towers for at least 8 years. Of these, 50% received wood treatment during the 8 years, or were to receive treatment thereafter. Under these conditions, maintenance and repairs are evaluated at an average of some 6.6% per year of tower first cost, excluding basin, electric wiring, and riser piping. Accumulated maintenance cost reached 25% of first cost after 6 years, 37% after 8, and was extrapolated to 100% after 15 years.

As to investment, the following figures are indicative: a conventional wood tower, such as Hamon also builds abroad, costs here, without basin, some $16 per sf of horizontal cross-section. An improved wood tower, with impregnated fill, asbestos-cement casing, etc, costs some $23. When clients seek high life expectancy under very adverse conditions, a conventional tower may have impregnated wood slats of increased size, transite casings, some plastic parts, etc. This runs cost to some $27 per sf, and tower fill is still wood!

As a builder of wood towers, Hamon has experience with their problems and for many years has worked in the direction suggested on page 10 of ASME paper No. 56-A-59: "Cooling tower owners . . . probably could have afforded a concrete-shell cooling tower with a fill of non-corrosive metal or some plastic material lasting perhaps 30 to 40 years." Hamon has chosen concrete shells and asbestos-cement fill for durable-material towers. These can tolerate pH of 8 or 9 and chlorinated water. In some cases, use of asbestos-cement avoids need for water treatment.

Asbestos-Cement Life over 40 yr.

Whether water is treated or untreated, there should be no fear of deterioration of permanent fill. In certain towers asbestos-cement used for flumes 34 years ago and for fill 20 years ago shows no change to date.

For induced-draft towers with concrete framework, columns and beams, corrugated asbestos-cement casing and transite fill, life expectancy is truly indefinite and exceeds 40 years with no question mark attached. The cost, in the order of $27 to $30 per sf, is similar to highly improved wood towers. Maintenance is nil.

Conclusions

Based on experience with all types, Hamon believes that a tower of durable material with asbestos-cement fill and life expectancy over 40 years will prove the best investment for most buyers of induced-draft towers.

Similarly, Hamon believes that hyperbolic towers with asbestos-cement fill offer maximum return on an investment that should be no greater than for wood-fill, because resulting smaller shell can be erected by an exclusive Hamon method.

To date, the Hamon companies have some 60,000,000 sf of asbestos-cement fill in service and thus have unique experience with this material.

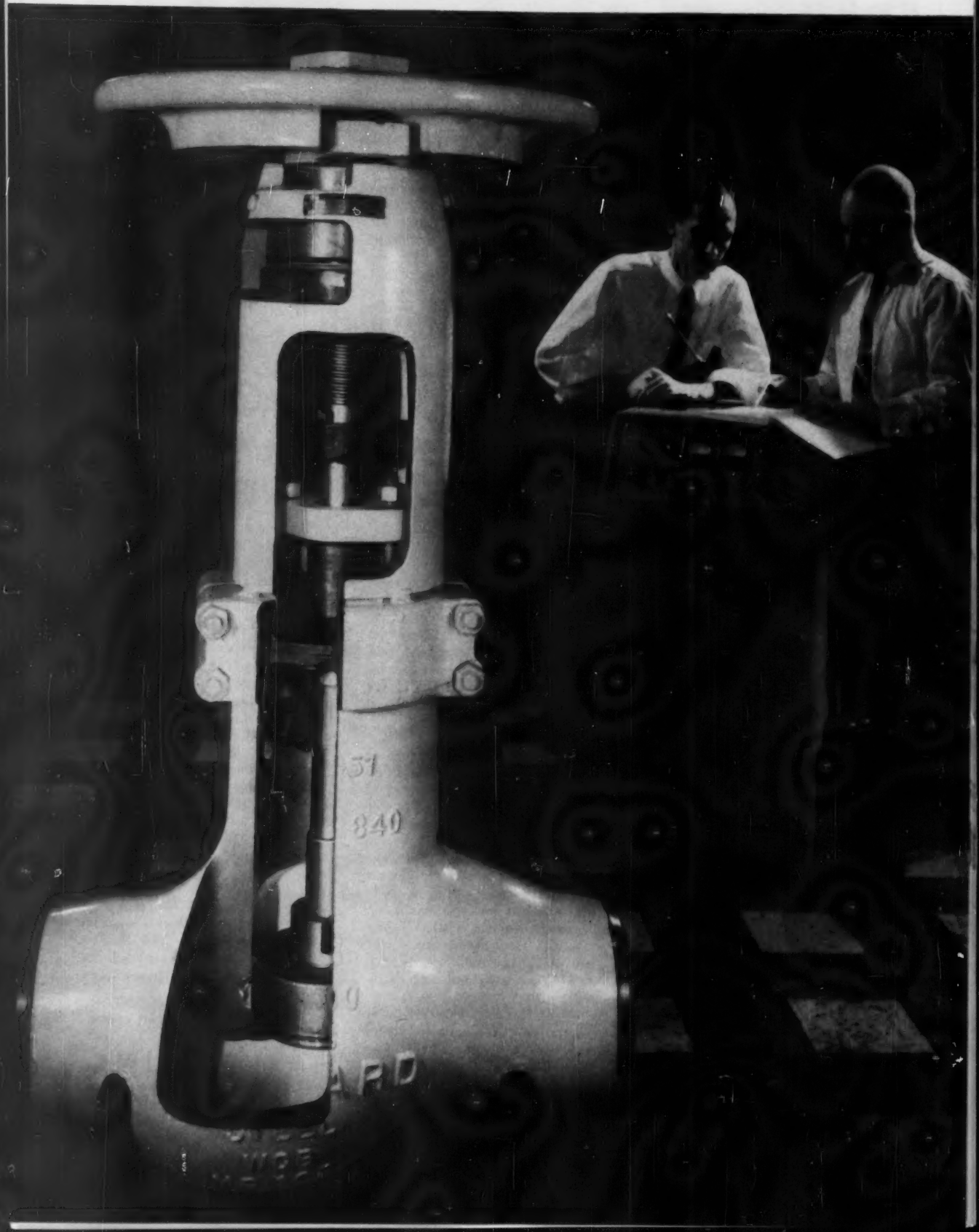
The above explains why Hamon, Inc brings its durable-material line to the attention of U.S. tower users.

For descriptive Catalogs on HAMON natural draft or induced draft cooling towers, write:

HAMON, INC.

224 South Michigan Avenue
Chicago 4, Illinois
Cable Address: ACHAMON, Chicago
Telephone: HArrison 7-0256

The Story of Edward Research



and the Pressure-Seal* Valve

The introduction, in 1945, of commercial steel valves with pressure-seal bonnet joint construction was a significant advance in the art of building large high-pressure steel valves. The new pressure-seal construction eliminated massive flanged bonnet joint connections and made it possible to seal the valves permanently at high temperature. These advantages were immediately apparent to users everywhere. But bonnet joint leakage problems developed on the new valves in service. And Edward engineers soon became convinced that the original 45° pressure-seal gasket design used by Edward and others required improvement. Here's the Edward pressure-seal redesign story:

INITIAL TESTING—Edward engineers began their studies on leak problems in 45° gasketed pressure-seal valves by determining under what conditions the valves were most likely to leak. It was discovered that when sealing areas were thoroughly degreased and tested with air, the pressure seal would leak at all pressures above 10 psi. In addition, minute imperfections in the sealing area of the valve body bore were preventing intimate gasket contact and contributing to leakage. Edward engineers found that a broader area of contact between gasket and bonnet and between gasket and body bore would also reduce leakage. Further investigation showed that a gasket plating material softer than the silver plating previously used would be helpful in achieving better contact in the sealing area.

To obtain more gasket sealing area, experiments were conducted on gaskets with angles from 45° down to 17°. Over a period of several months, tests were made with 25 different combinations of gasket and bonnet angles and various gasket plating materials. Assembled valves were tested for tightness with air pressures ranging from 10 psi to 2160 psi, and at temperatures up to 1000 F for extended periods. And tests on ease of valve disassembly (an important user consideration) were made with each gasket combination.

TEST CONCLUSIONS—At the end of their extensive testing program on the pressure-seal design, Edward engineers were able to draw these conclusions:

1. 45° gaskets, which showed no leak on water tests, leaked air at similar pressures.
2. No gasket of any design, either plain or with a plating of 100 Brinell or harder, would seal air when assembled unlubricated.
3. The best sealing under test resulted with a 25° gasket angle which was 1° more acute than the bonnet angle.
4. Gaskets of 25° angle actually tripled the sealing surface area.
5. A stainless inlay in the valve body bore sealing area substantially improved gasket-to-body contact and provided a corrosion-resistant surface.
6. Gaskets of 25° angle, plated properly with a malleable coating, gave perfect air or steam sealing at all temperatures, whether assembled dry or with a lubricant.

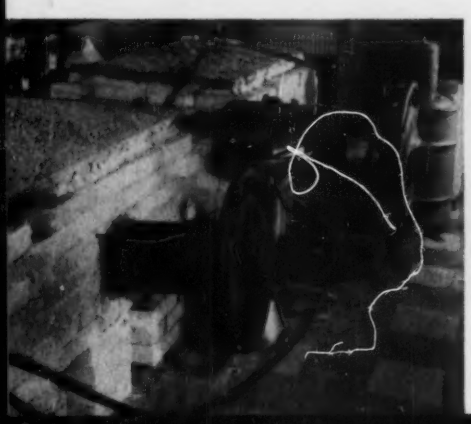
NEW VALVE DESIGN—As the result of their tests, Edward engineers designed the completely new pressure-seal valve with 25°-65° joint (see diagram below). This change in gasket angle, with an increase in sealing surface area, and the addition of a special corrosion-resistant malleable coating, brought an end to bonnet joint leakage in Edward pressure-seal valves. And, since 1953, thousands of Edward pressure-seal valves have been installed in a great variety of services *without a single case of failure reported to date.*

The story of Edward research and the pressure-seal valve is typical of the kind of research progress and product leadership you can expect from Edward Valves. Edward builds a complete line of forged and cast steel valves from ¼" to 18" for industrial, marine, petroleum and technological services. For more detailed information, contact your Edward Representative, or write Edward Valves, Inc., 1230 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 438 St. Peter Street, Montreal.

*Patented

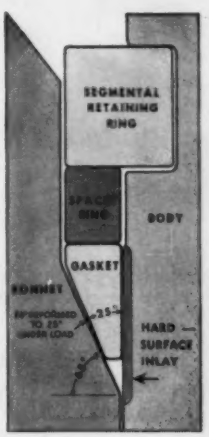
EDWARD STEEL VALVES
another fine product by
ROCKWELL

P. J. DUKES, product development engineer, and D. MacGregor, works manager, are shown with helium leak detector used in testing pressure-seal valve joints.



SPECIAL GAS-FIRED FURNACES were used in temperature testing of new pressure-seal valve design. Furnaces heated valves up to 900 F for 24 hour periods. Pressure was maintained with hydro-pneumatic pumps.

NEW 25° GASKET DESIGN



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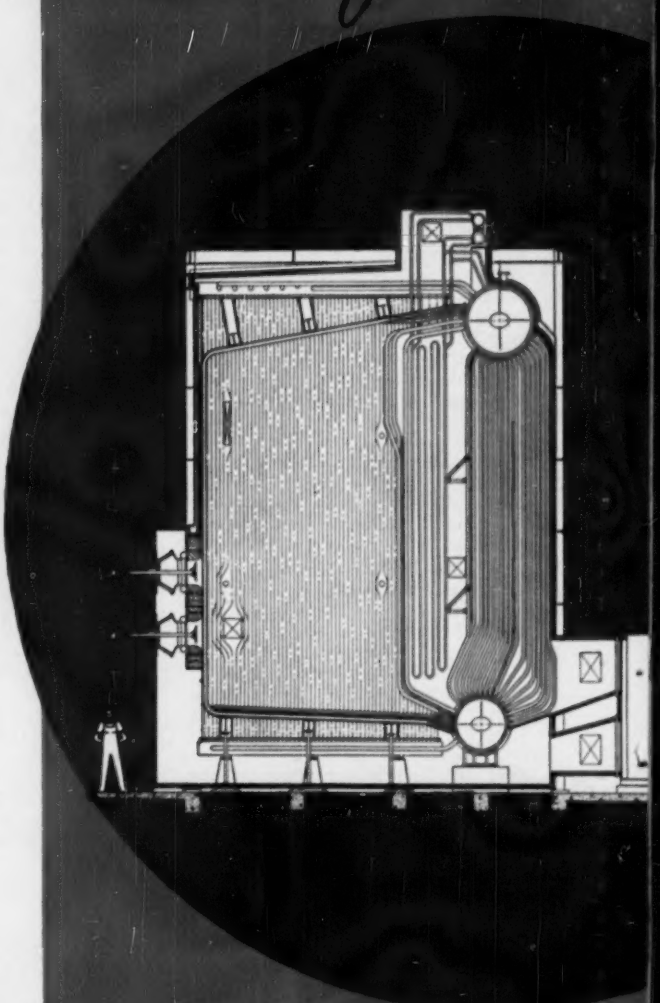
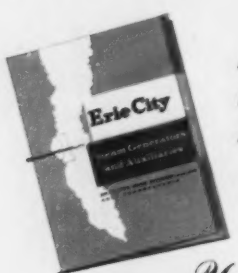
Erie City Multi-pass Pressurized 2-drum Steam Generators are quality designed and quality built for long life and low maintenance. These generators require forced draft only, thereby eliminating the expense and maintenance of the usual additional induced draft equipment . . . also simplifies combustion control systems.

The Erie City Pressurized 2-drum Steam Generator features a welded **inner** seal casing and a welded **outer** casing—**each independent of the other.** The welded inner seal casing is attached to the pressure parts of the unit and expands and contracts as the unit breathes. The outer casing is attached to the structural steel supporting members and remains rigid. The use of properly designed expansion joints allows the pressure vessel and the inner casing to expand and contract in unison with no effect on the outer casing and structural members.

We invite comparison to the Erie City Pressurized 2-drum Steam Generator. Why don't you invite an Erie City Engineer to point out the many advantages of our unique design?





Available for your study of Erie City Steam Generators and Auxiliaries is catalog SB-6101-M

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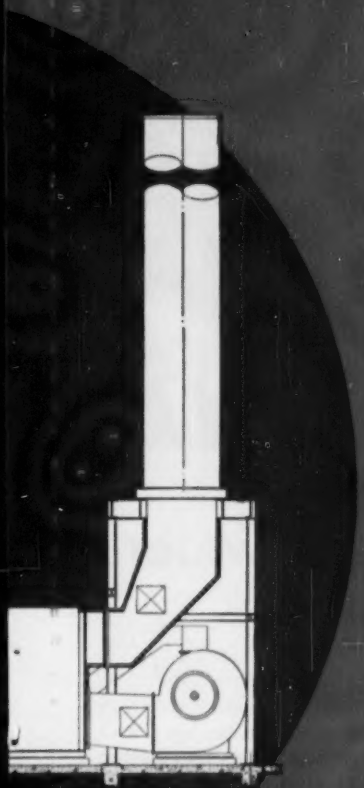
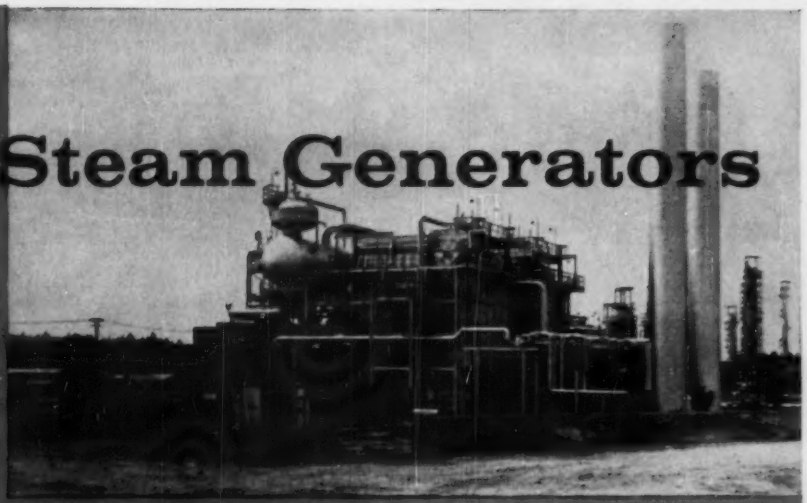
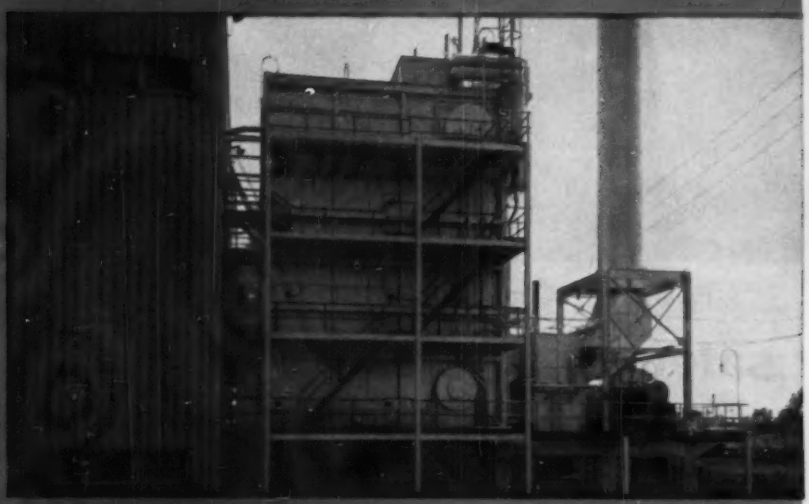
ECONOMIZERS · WASTE HEAT BOILERS · OIL and GAS BURNERS
AIR PREHEATERS · FIRE and WATER TUBE PACKAGE BOILERS

—2-drum Steam Generators

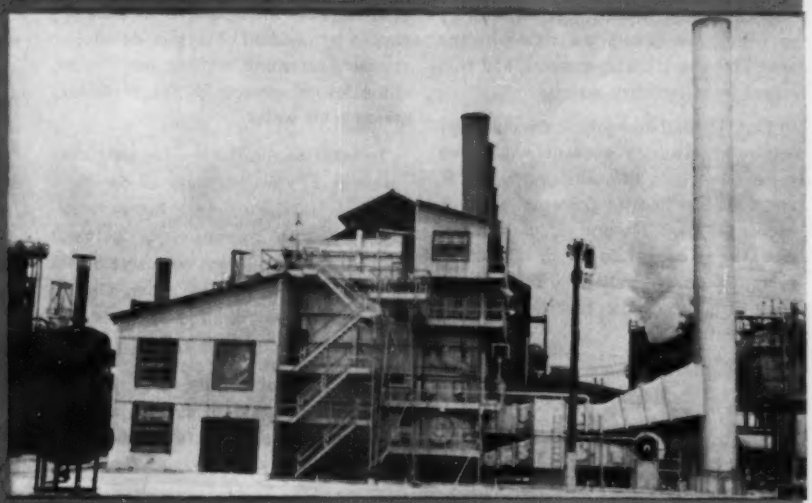




West Coast Oil Refinery's 4th two 225,000 lbs./hr. pressurized units — 785 lbs. design pressure — 700° F. steam temperature — gas and oil fired.

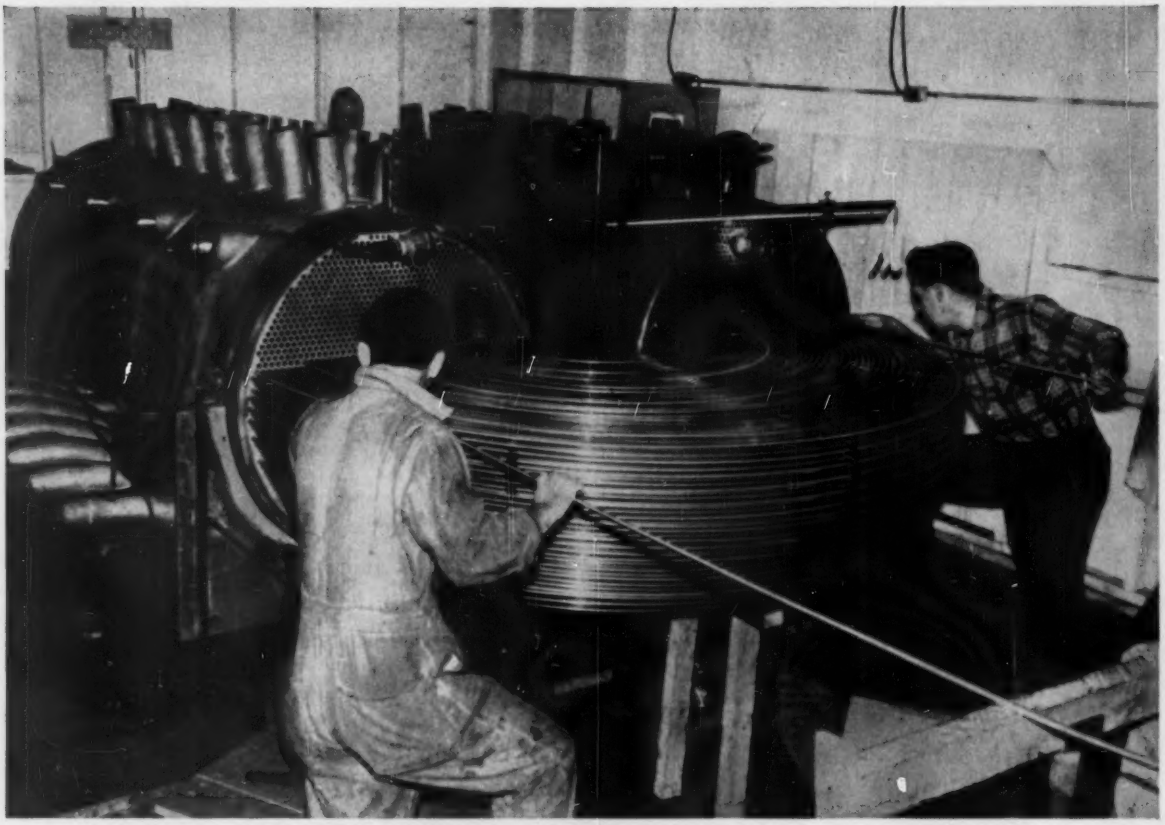


An Oklahoma Municipality has one 150,000 lbs./hr. pressurized unit designed for 725 lbs. pressure and 825° F. steam temperature — gas and oil fired.



In Illinois a petroleum refinery uses one 120,000 lbs./hr. pressurized generator — 300 lbs. design pressure — gas and oil fired.

For more facts circle 234 on Reader Service card, p 139



Builders of Canada's first commercial pressurized-water reactor, NPD-2,

safeguard tubes for "hungry" heavy water against corrosion with Inconel

Many advanced design concepts are incorporated in Canada's NPD-2. One of the most interesting concerns the selection of Inconel* nickel-chromium alloy to prevent corrosion of tubes in the heat exchanger that generates 410 psig steam from ordinary water.

This U-shell-and-tube exchanger receives high-purity pressurized heavy water heated in the reactor to 530° F, and uses this heat to generate steam in exchanger shell. Natural circulation carries the steam into a drum where cyclones remove moisture. Then steam goes directly to the turbines without superheating.

Designers make a considered departure

In selecting material for the heat exchanger tubes, the designers** were concerned with safeguarding against several forms of localized corrosion which might cause serious future difficulties . . . i.e., cracking or intergranular weakening caused by residual or service-developed stresses, alternate wetting and drying, chlorides or oxygen in the secondary steam cycle water.

In addition, on the reactor side, they wanted: (1) no build-up of corrosion products in the primary heavy water and; (2) no formation of galvanic couples that accelerate corrosive attack on one member or the other. On the steam side, they wanted to avoid any possibility of copper pickup.

After extensive studies and tests, alloys hitherto used in similar applications were ruled out in favor of Inconel alloy. Not only does Inconel alloy show up well on all the above counts, it also provides excellent strength at high temperatures. What's more, the low Cobalt content is desirable when maintenance eventually becomes necessary.

As for the tubing itself? The Huntington Alloy Products Division produces it . . . in lengths up to 85 feet and pre-bent. Every length is ultrasonically inspected. Orders are filled promptly.

If you would like more information on Inconel alloy write for our Technical Bulletin, "Engineering Properties of Inconel".

*Inco trademark

**Heat exchanger for NPD-2 was fabricated by Babcock & Wilcox (Canada) for The Canadian General Electric Co.

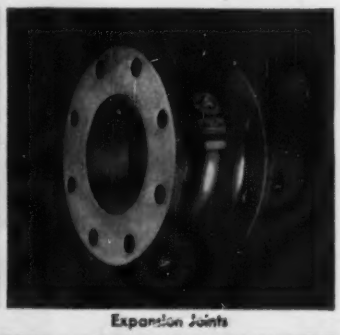
HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCONEL®

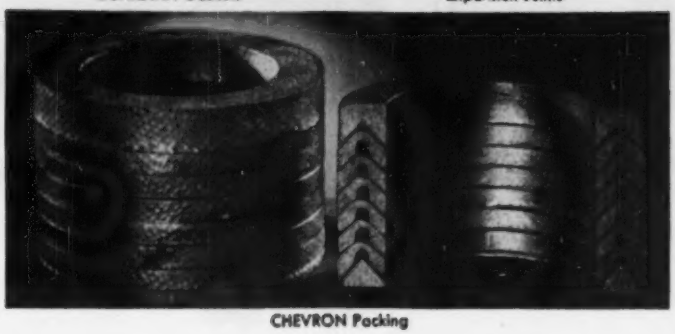
For more facts circle 253 on Reader Service card, p 139

ENGINEERED PRODUCTS for Plant Maintenance

GUARDIAN Gaskets



Expansion Joints



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GARLOCK

and warehouses throughout the U.S. and Canada. Or, write for catalogs. Garlock Inc., Palmyra, New York.

Canadian Div.: Garlock of Canada Ltd.

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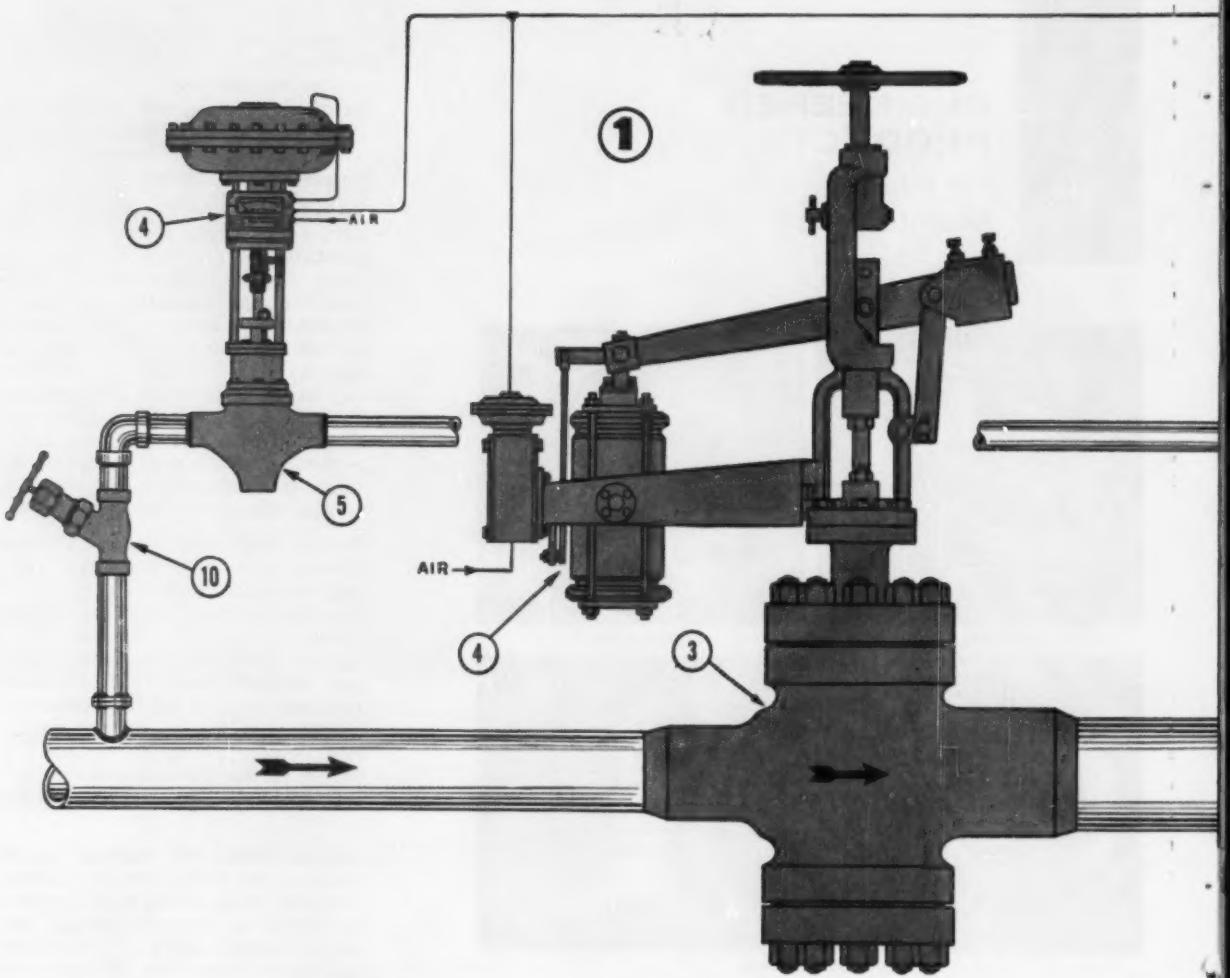
Pressure Reducing and



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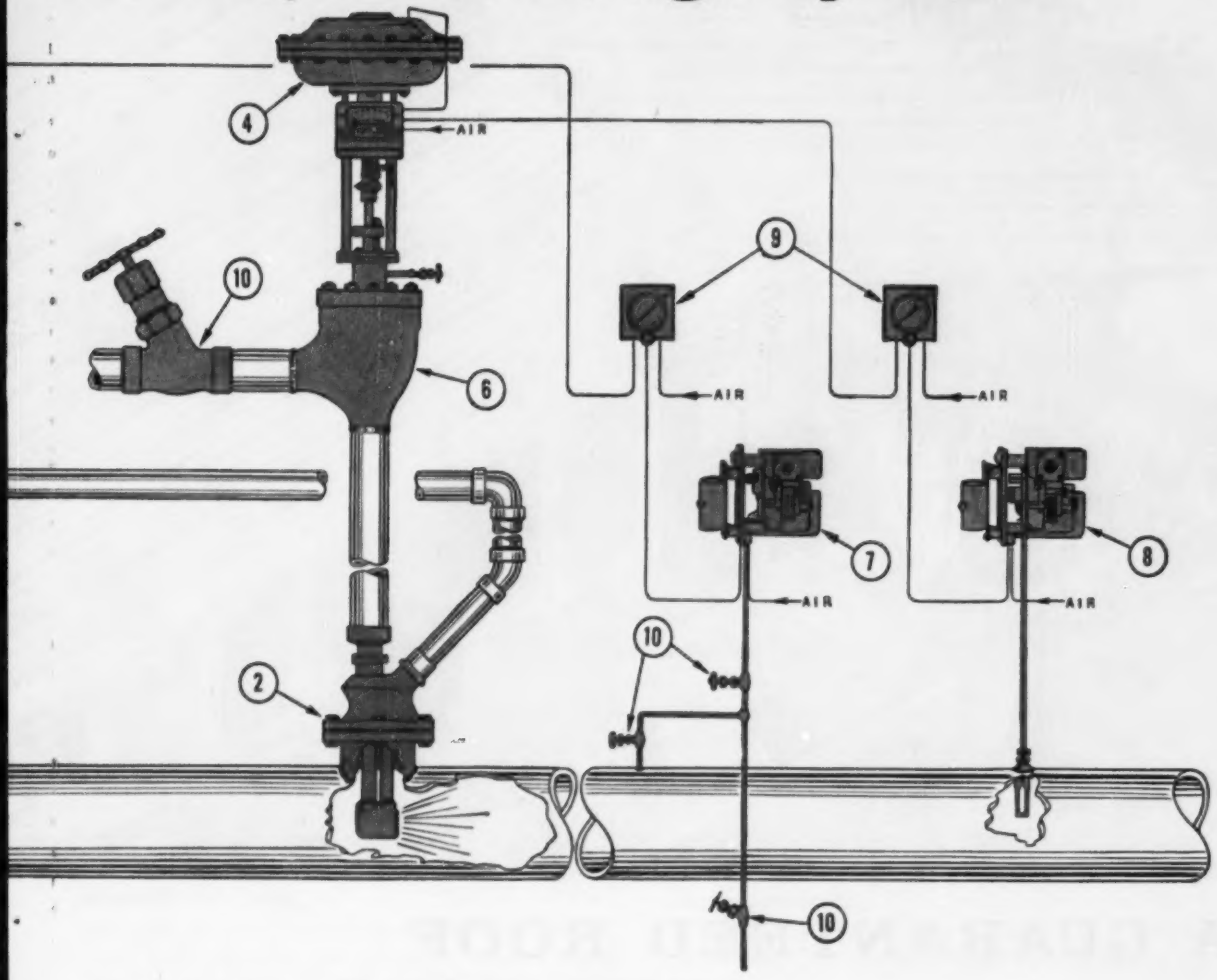
Desuperheating System



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Here's another reason to "go Butler" for your new building this year. You can have a preferred aluminum roof so superior that we are now able to offer a *20-year guarantee.*

This is the first long-term roof guarantee ever offered for pre-engineered buildings. It is made possible by Butler's leadership in designing and fabricating an enduring, weatherproof aluminum roof system that today has an impressive history of outstanding job performance on thousands of Butler Buildings. Be sure that this new development in roof security, optional at nominal extra cost, is considered in your new building plans.

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"See Sweet's Industrial Construction File—Section 9-B"

MBMA

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Just scoop the dry acid cleaner from lightweight, disposable drum into make-up tank. Often can be added directly to steam-generating, condensing and similar equipment . . . no elaborate apparatus or specially trained personnel required.

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Please send me quick facts bulletin on Dry Acid Cleaners, names of formulators offering cleaners based on Sulfamic acid.

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Company_____

Address_____

City_____ State_____

circle 237 on Reader Service card, p 139

For more facts circle 238 on Reader Service card, p 139

Background photo shows Cooper-Bessemer FM compressors for soot blowing service in a large western utility.

ECONOMICS OF BOILER CLEANING WITH COMPRESSED AIR (Versus Steam)

1. Pressure is always adequate to do a fast, thorough job.
2. Better programming with air gets better cleaning results for higher boiler efficiency.
3. Lower cost for blowing medium — less waste.
4. No quenching action on hot alloy tubes or pressure vessels.
5. Much less maintenance of blower equipment due to erosion, corrosion, packing wear.
6. Improved housekeeping — no steam or condensate leakage.
7. Greater over all economy of blowing medium on evaluated basis.
8. Eliminates condensate makeup required when blowing with steam.

For more facts circle 239 on Reader Service card, p 139

Soot blowing with air is faster, cleaner, less costly

...a report on soot-blowing applications by
L. B. Schueler, *Power Plant Consulting Engineer, The Cooper-Bessemer Corporation*

The big reason why power companies and their consultants are switching from steam to air for soot blowing is *to reduce costs.* Compressed air does the job more thoroughly, uniformly, with less mess and at less cost. Its high efficiency increases the capacity, availability and economy of the entire furnace and boiler! Total maintenance cost is very much lower.

The whole story is given in the reprint of an article, "Steam or Air: Which costs more for boiler cleaning?" Write for your free copy. We will gladly work with you on your plans for compressor facilities for soot blowing . . . or other power plant needs. Call the nearest office.

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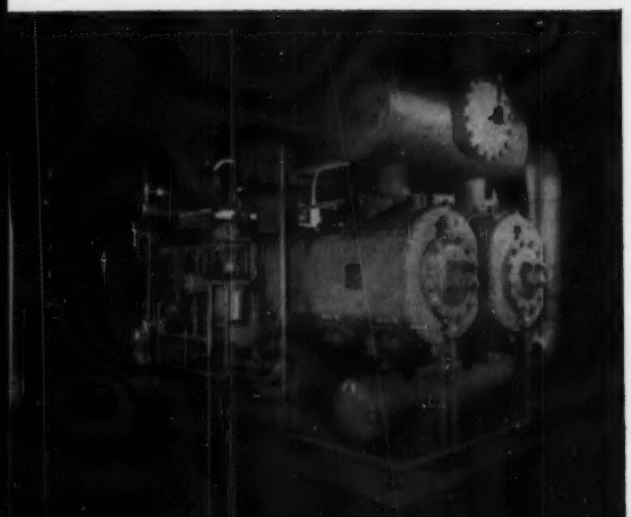

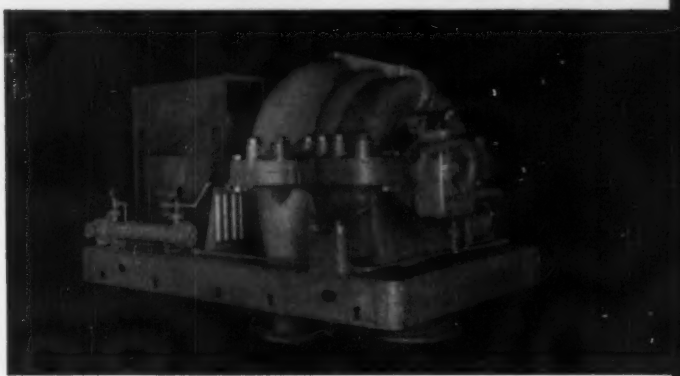

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For more facts circle 240 on Reader Service card, p 139

LOUIS N ROWLEY, EDITOR • DECEMBER 1960 • ESTABLISHED 1882 **Power**

Now is the time!

Most of us would agree, I'm sure, that industry seems to use an increasing amount of electrical energy per unit of output, although we might be hard put to cite statistics to prove it. Just the other day I ran across a report that confirmed this point and, more significantly, went on to make another point of considerable consequence to energy-systems engineers.

The report, by a well-known economic analyst, used the Federal Reserve Board index of industrial production as a measure of output. In each of the 15 postwar years except two—1950 and 1958—*consumption of electricity by industry has increased per FRB index point.* And this is to be expected, because substituting kilowatt-hours for manhours is a key means of increasing productivity.

Also as you would expect, periods of sharply rising industrial production coincide with periods of rapid increase in industrial power sales by electric utilities. During the years 1947 to 1955, when industrial growth was rapid, industrial power sales increased by better than 9% per year. In the slower growth years, 1955 to 1960, industrial power sales also grew at a slower rate—5.9%. This slower rate is expected to hold for a while.

But—and here is the point of significance to energy-systems engineers—this report forecasts a return to a 9%-per-year rate of increase for industrial power sales beginning in 1964-'65 and continuing for the remainder of the 60's. This is predicated on the analyst's belief, shared by many other economists, that industrial production will expand at a higher rate during the last half of the 1960's.

Now a 9% growth rate may not seem like much, but remember that this means a doubling in the industrial use of electricity in the short period of eight years. And then think what this means in terms of needed expansion for in-plant electrical-distribution systems.

In spite of consistent emphasis in our "Power to grow . . . *electrically*" program and similar efforts sponsored by others, the electrical systems of U.S. industry are, in all too many cases, far from ready to handle an expansion of this kind. Here then is a clear warning, and a time to act.

Now, before the rate of expansion zooms, is the time to modernize industrial electrical systems, to build into them the ability to expand economically that is the essence of the "power to grow" idea. For a modest investment now, plus foresighted planning, you can insure an in-plant electrical system that will be ready for the bigger loads to come. And the total investment will be but a fraction of what would be involved if you waited until the expansion wave hit and had to revamp or replace your system on an expensive "crash" basis.

OWNER: *Public Service Company of Colorado*
ARCHITECTS: *G. Meredith Musick & Clayton C. Musick*
ELECTRICAL CONSULTANTS: *Swanson — Rink & Associates*
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TOTAL FLOOR AREA: *77,400 square feet.*

Electrical Protection goes MODERN *with* BUSS Fuses...

in the New Service Center of the Public Service Co., of Colorado

This recently completed service center, — located at 2701 West 7th Ave., in Denver, Colorado — has fuses installed throughout the entire electrical system.

The primary voltage at the underground transformer vault is 13,800 volts, 3 phase, 4 wire. Secondary voltage is 120 and 208 — 3 phase, 4 wire.

Installed in the main service entrance are BUSS Hi-Cap fuses; the sub-feeders are equipped with FUSETRON dual-element fuses and the lighting panels are protected by BUSS Fustat fuses.

Modern electrical protection calls for fuses because — fuses cannot be equalled by any other type of protective device for their combined high interrupting capacity, lifetime dependability and maintenance-free features.

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The revolutionary new protective device

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Fusetron dual-element fuses meet todays' demand for safety. They have an interrupting rating of 100,000 ampere rms symmetrical — and for protection of mains or circuits above 600 amperes, BUSS Hi-Cap fuses are designed to safely interrupt 200,000 ampere rms symmetrical.

And fuses remain safe and accurate through the years. They require no expensive maintenance or recalibration — they are always ready to function the instant trouble occurs.

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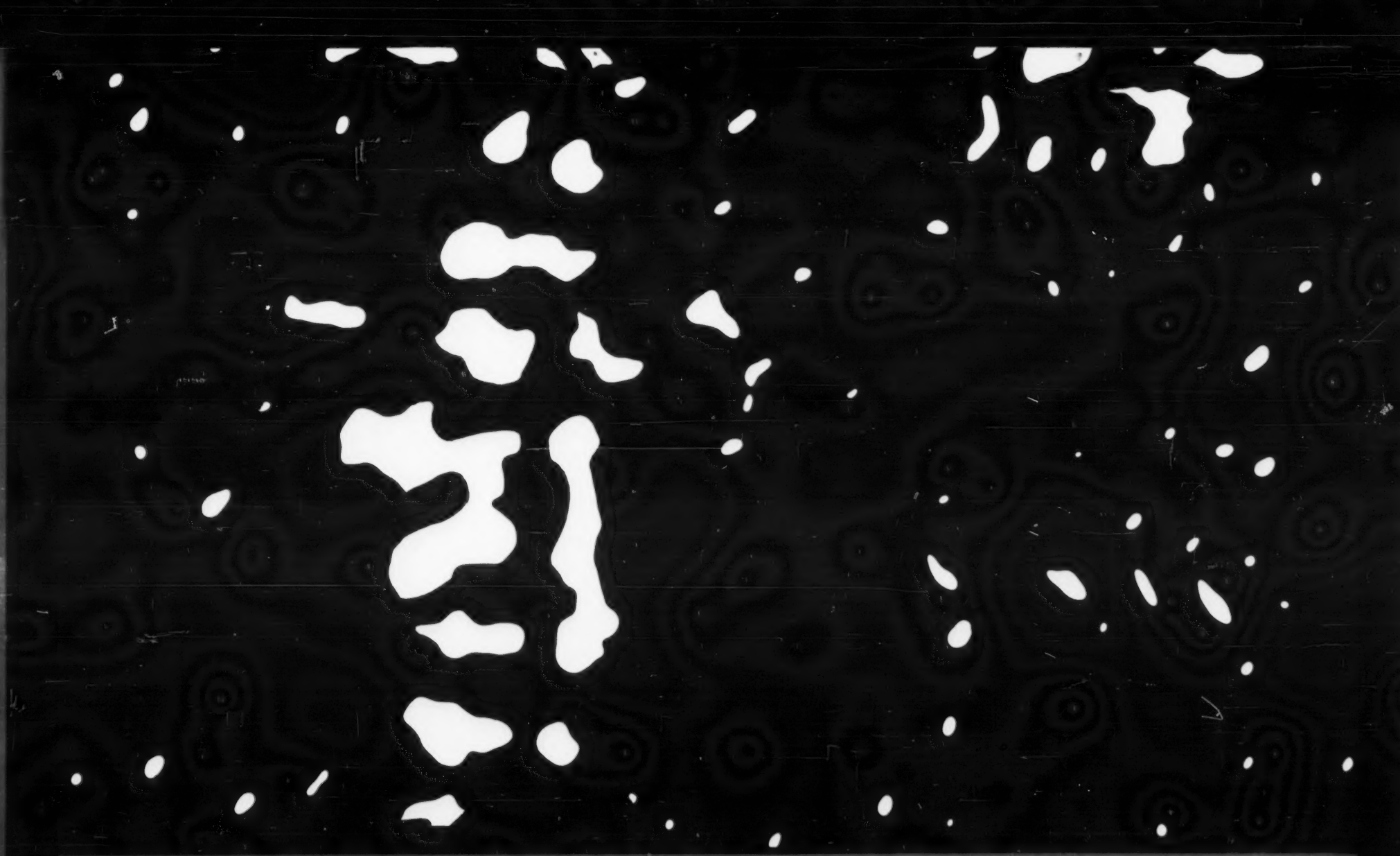


Power — December 1960 — a special report

airpollution

Air pollution is by no means a new problem: records show efforts at control as early as the 14th century. But where this once was a matter of concern in a few unusual situations, population growth and concentration now give pollution control importance and urgency in many communities. Nor is the answer any longer a simple one. While our technical resources for diagnosis and prescription are greater than ever, the multiplying diversity and complexity of human activities make both vastly more difficult.

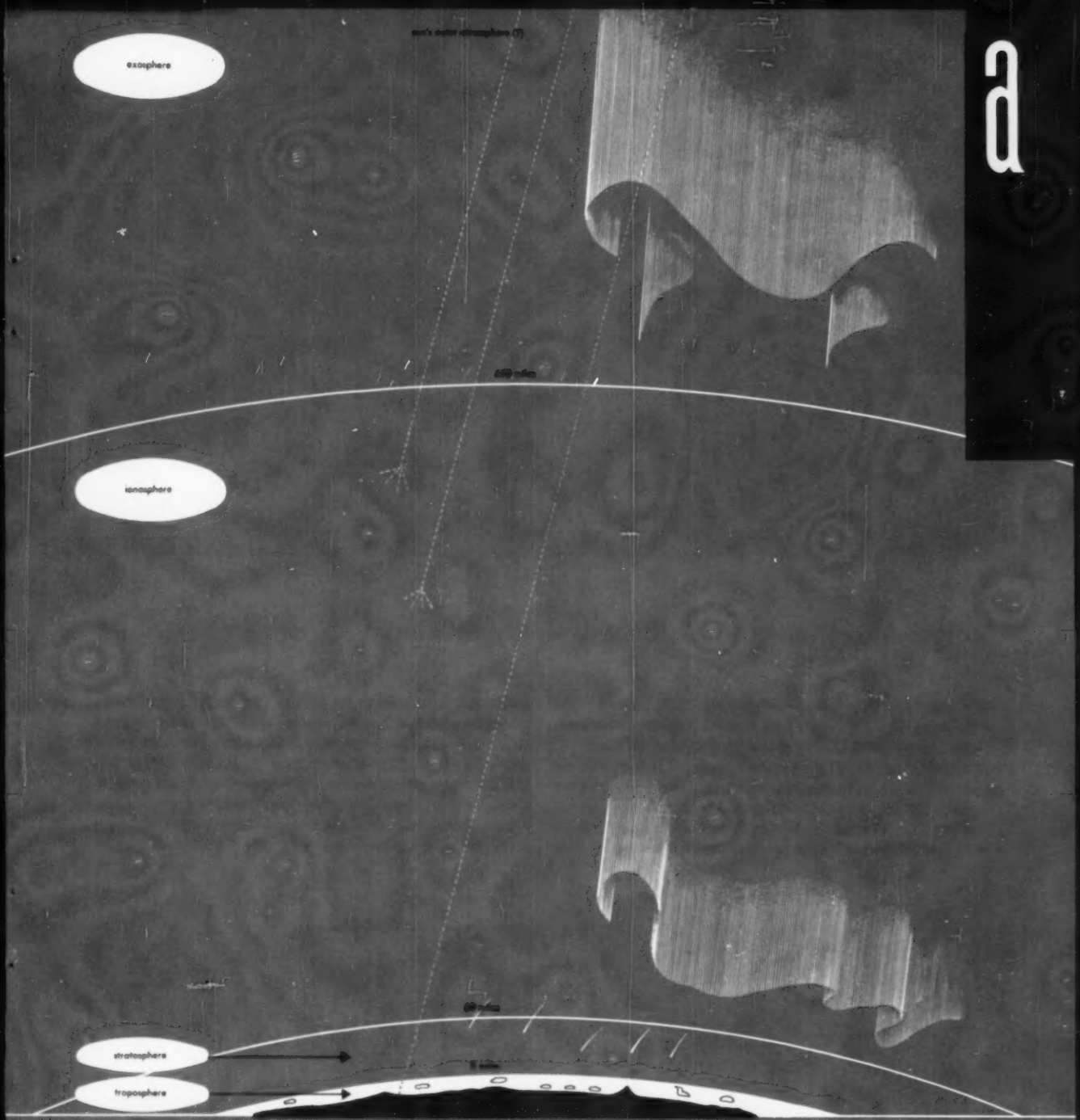
Thus, while pollution affects more and more people, it becomes increasingly a problem for the specialized skills of the engineer. It demands these skills in two areas. One is a responsibility engineers have recognized and accepted for many years—the application of their know-how to the direct and practical task of designing and operating plants and facilities that, taken individually, are good citizens from the pollution standpoint.

Now, as never before, engineers must recognize and accept another kind of responsibility—as individual citizens of their communities. Compared to the job of cleaning up a single stack, the task of cleaning up a region's air is infinitely complex and full of pitfalls for the technically unwary. Only too often it is approached in an atmosphere where emotion and ignorance outweigh judgment and knowledge. To this situation the engineer-citizen can bring the leaven of logical, informed thinking, a dispassionate desire for the right answer rather than the expedient one.

If community efforts to achieve clean air are to reach fruition, the engineer needs to raise his sights from his own plant to encompass all aspects of pollution, while the enlightened citizen needs some technical understanding of the nuisances he seeks to limit. As an aid to both, POWER editors began more than a year ago to research each phase of air pollution. From their digging into source materials, interviews with authorities, on-the-spot investigations, comes the special report that follows.

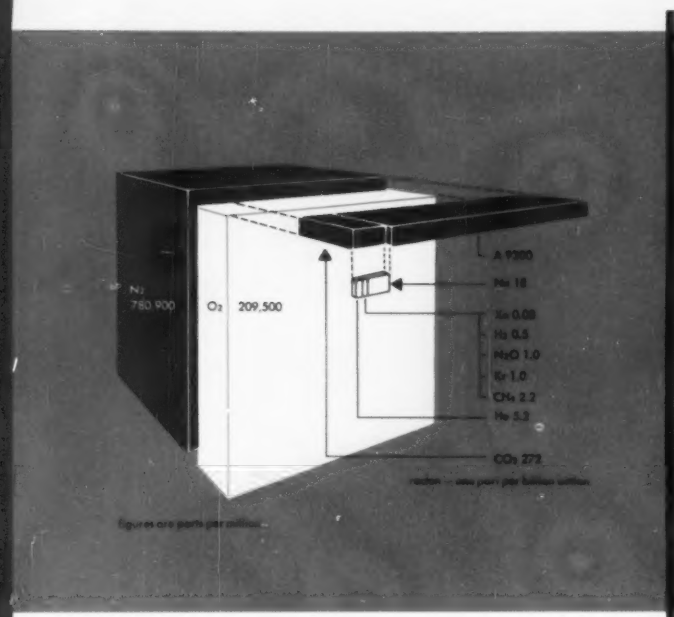
To put the manifold aspects of the pollution situation into perspective, the report deals first with the great ocean of air in which man lives and works. Then it takes a wide-ranging look at the many ways that living and working produce pollutants. With the elements of the problem identified and their interplay explored, the report then presents constructive approaches to solutions for the community and for the individual plant.

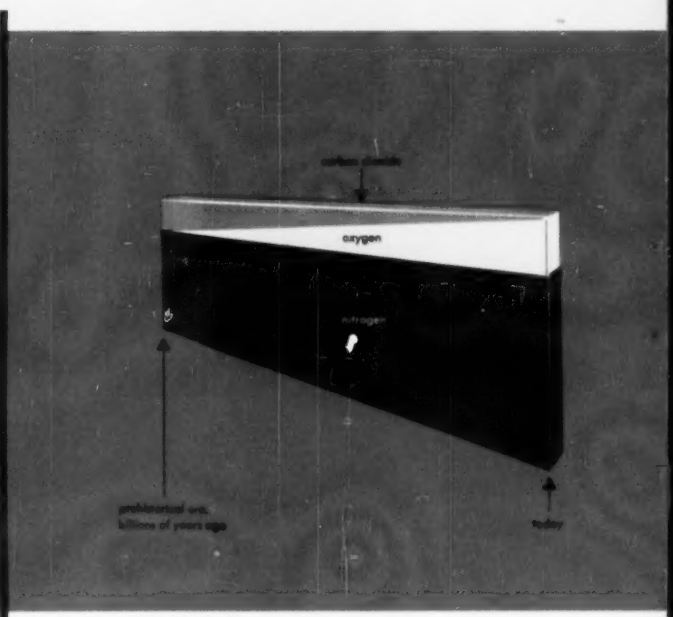
We hope that engineers accustomed to daily concern with plant pollution control will welcome this broader view. And we hope that civic leaders and public-spirited citizens of America's communities will find here the essentials for acting with wisdom in a matter of ever-increasing urgency.



Our ocean of air: Stretching toward outer space, earth's atmosphere displays ever-changing facets of composition and behavior. Most important to us is the restless troposphere, that thin layer, only 5 to 11 miles deep, next to our planet's surface. This region of seething activity, from storm to balmy day, has for an overlay the austere and serene stratosphere, never-changing and weatherless. Then comes the incredibly thin air of the ionosphere. Cosmic-ray bombardment gives its atomic particles electric charges, making it a useful reflector of radio waves from the earth. Far out, the ionosphere merges into the exosphere. Some believe this may be the sun's outer atmosphere.

As we rise through the earth's atmosphere, pressure steadily lessens until it all but vanishes in the exosphere. Temperature gyrates fantastically with altitude as the endless spinning of the earth and its surrounding air changes the energy balance.



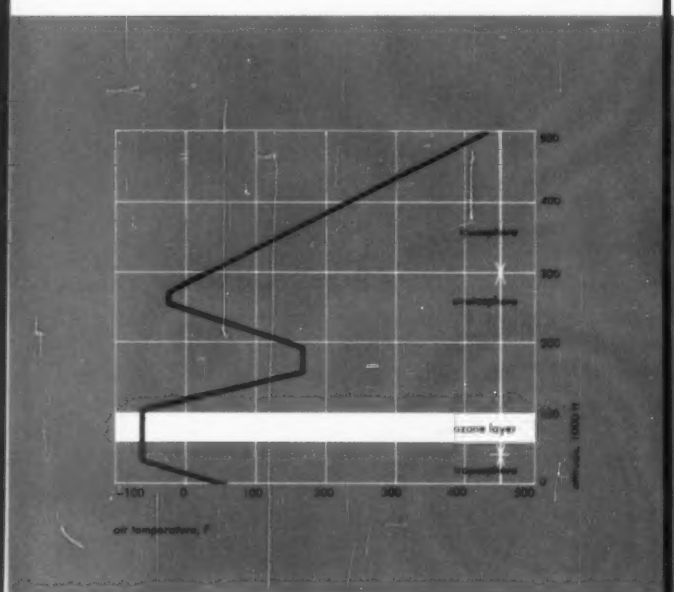


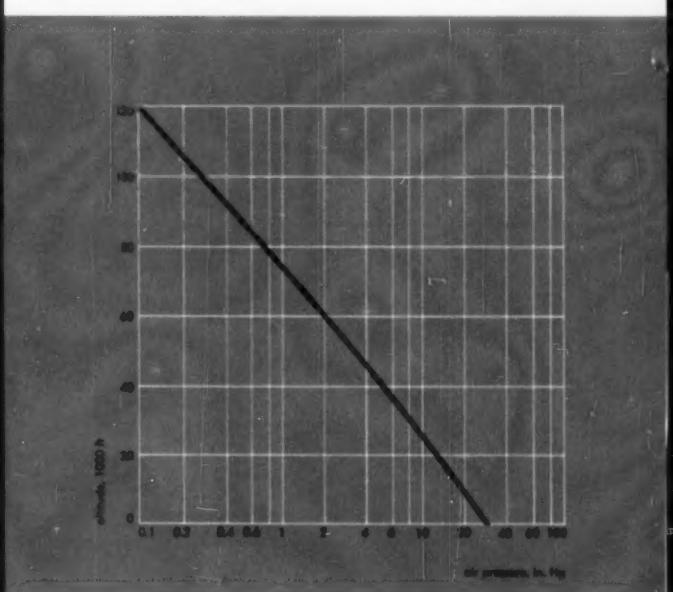
The troposphere, in which we live, is made up of many elements...

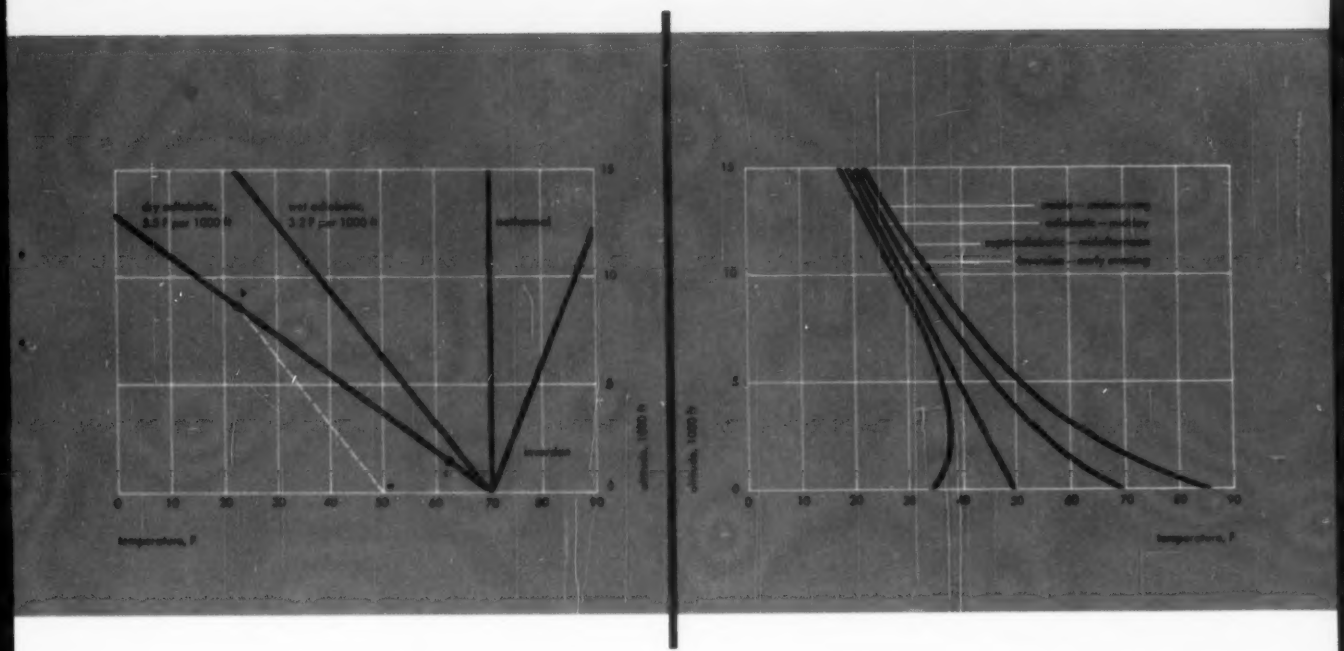
Of air's many elements, the most important are nitrogen and oxygen. Diagrams above show the present makeup of the troposphere and the change believed to have occurred during eons of geological history. There was probably no free oxygen present during earth's creative convulsions; it was most likely formed by plant life.

As we rise through the troposphere the air thins rapidly —pressure falls to microscopic levels as fewer and fewer molecules rise to high altitudes. But the air holds surprises. As we first ascend, it drops to frigid temperatures, and then oscillates back and forth until finally it gains searing levels in the upper reaches of the exosphere. Below left, we have the trend of temperature change with rising altitude, but this is no fixed relation.

In the habitat of living things, temperature changes continuously. In the lower layers of the "thick" atmos-





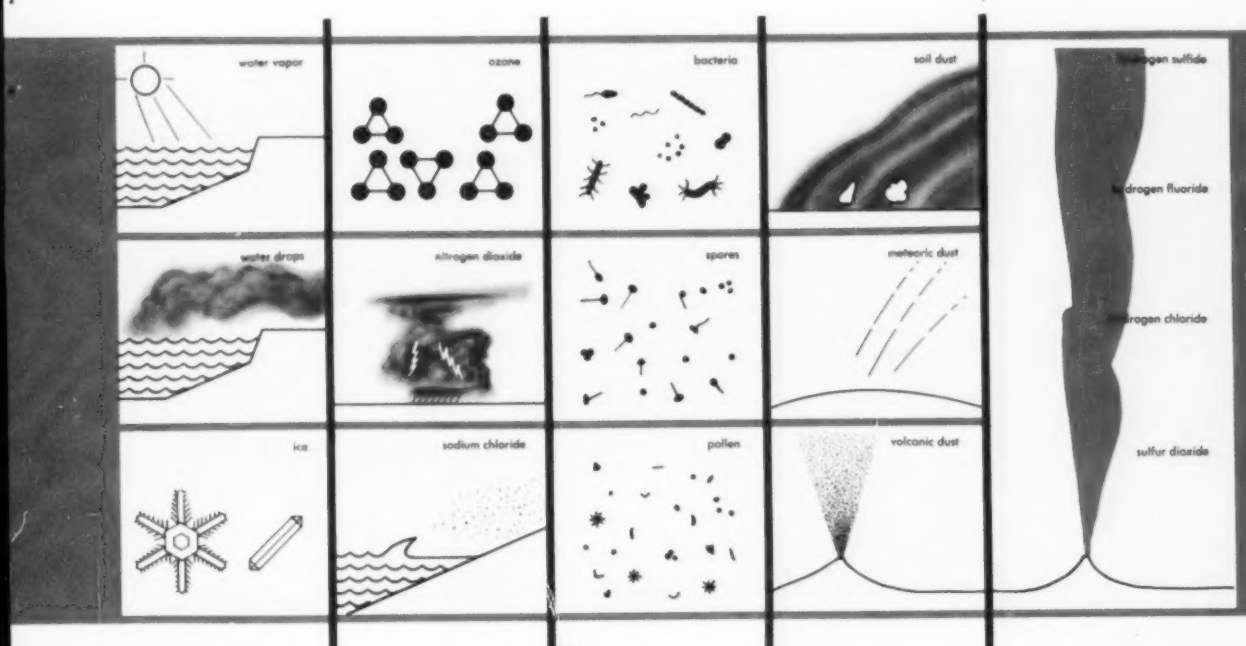


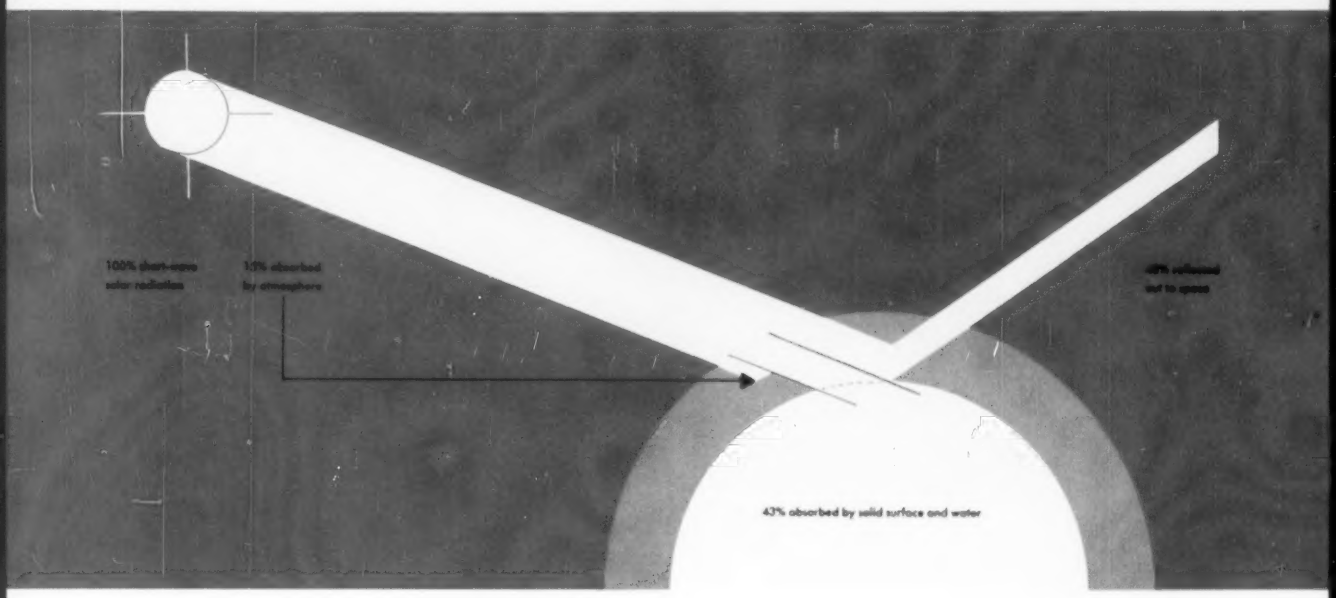
...acts in often complex ways, even carries "natural" pollution

phere we find that air cools with rising altitude, above left. But its rate of change depends on the entrained water vapor (humidity) and momentary gain or loss of thermal energy at all altitudes.

The change in temperature we call the *lapse rate*. Dry still air cools at 5.5 F per 1000 ft, while moist air cools at 3.2 F only. Sometimes the air has a constant temperature at all altitudes, and then again temperature may rise with altitude. The flow of energy through the universe persistently changes the lapse rate of a locality during a 24-hr daily cycle as typified at upper right.

The restless darting molecules of air carry with them many particles and gases flung up by the forces of nature. These natural pollutants, some of which are diagramed below, would exist in the atmosphere even if man had never set foot on this ancient planet of ours.

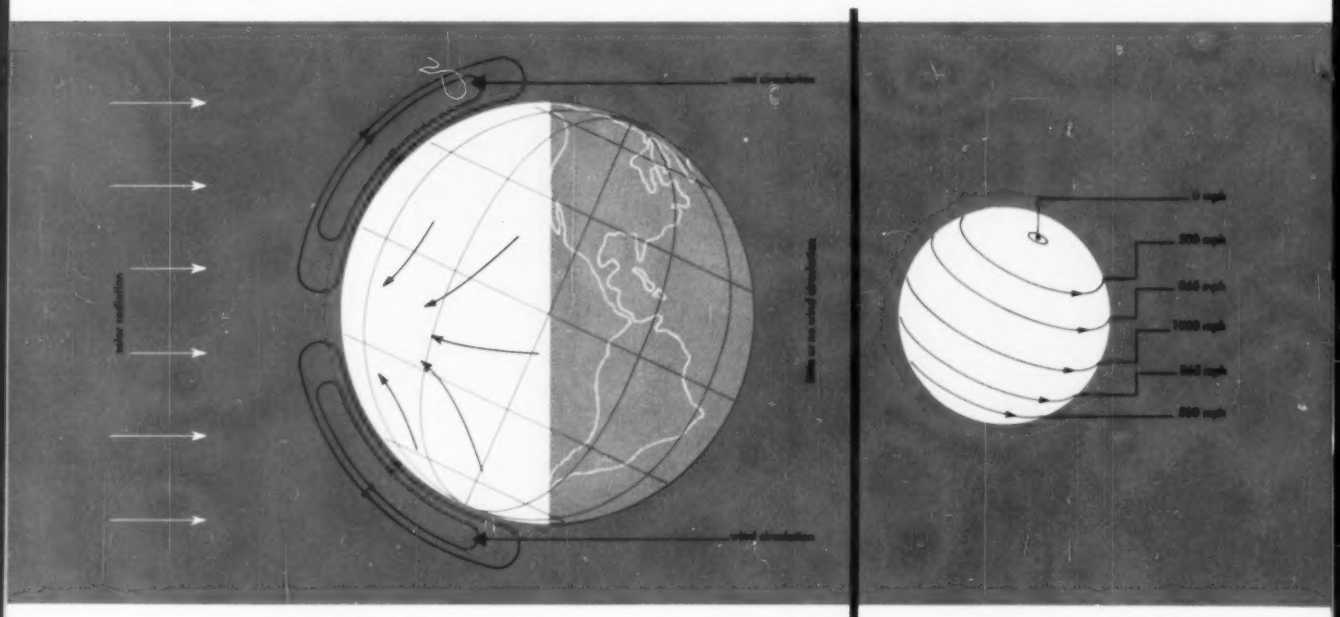


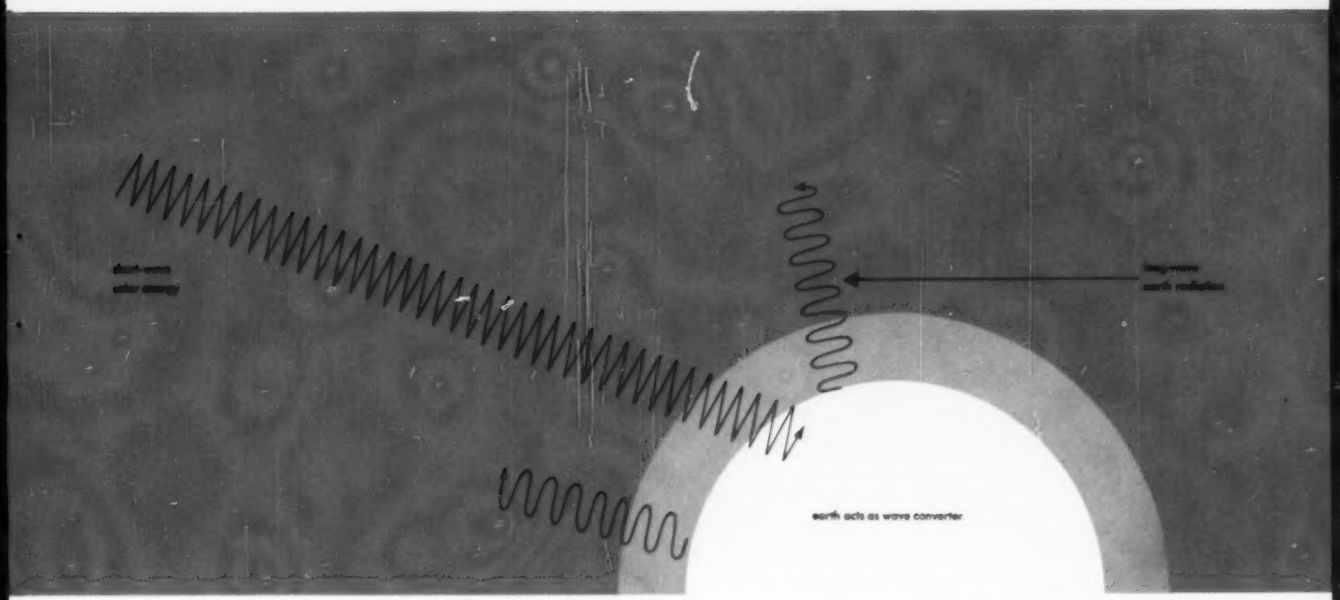


Solar energy conversion, the earth's inclination and rotation...

The earth's share of the sun's nuclear-generated radiant energy is paltry, but it runs our weather system. In terms of averages the atmosphere directly absorbs only about 15% of the energy received; 42% reflects back to outer space and 43% is absorbed by the earth's varied surface. The earth acts as an energy converter; it receives short-wave light energy and changes it to long-wave heat energy. This warms our airy envelope and makes it move: ultimately the heat energy radiates to outer space. The air acts like a greenhouse, passing short-wave radiant energy but absorbing long-wave heat energy.

If the earth did not rotate to produce alternating day and night we would have a fixed wind pattern, lower left. Surface winds would blow to the hottest part of the globe and there rise as they heated by conduction from the warm earth. Welling up toward the stratosphere, the air

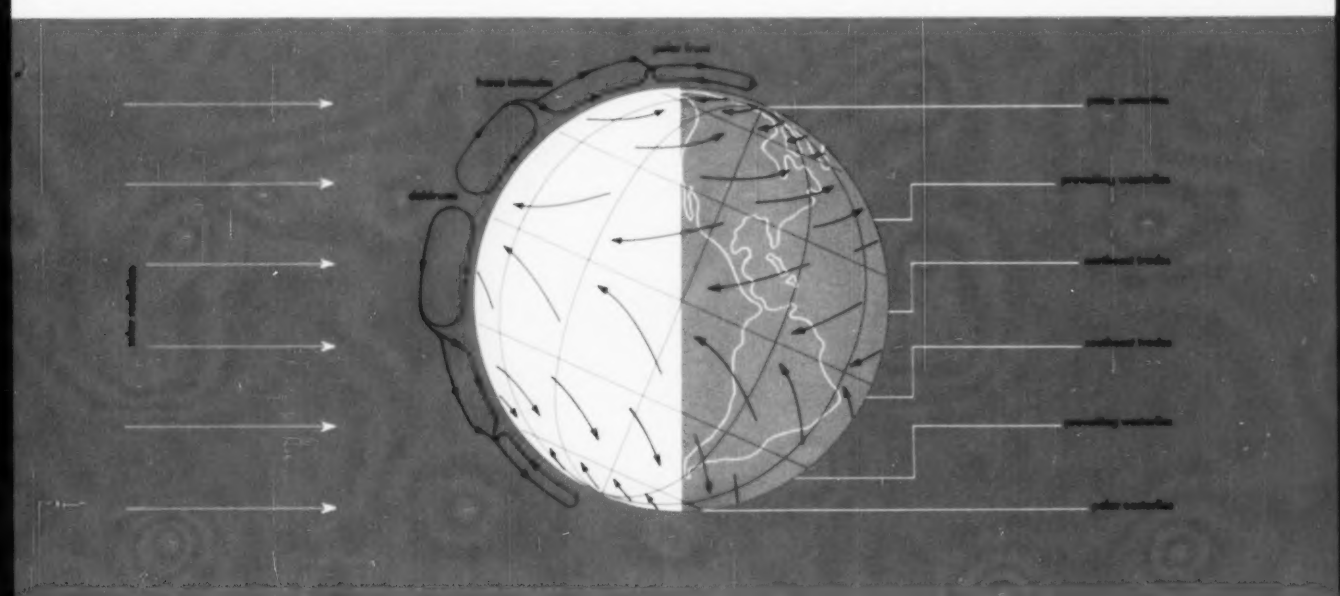


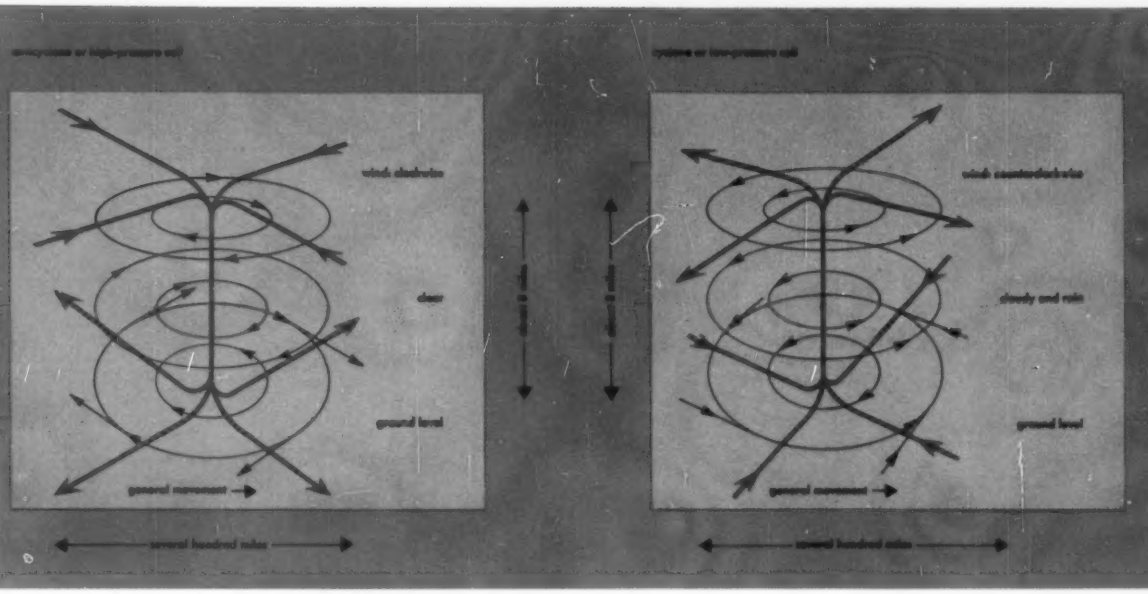


...are among factors causing general atmospheric motion patterns...

would cool as it worked against gravity. In the upper troposphere it would sweep out in all directions toward the wide-flung dark, cold parts of the globe. Here the upper winds would sink as they cooled and again head for the hot spot on the surface directly under the sun.

But the earth turns on its polar axis, and its linear speed varies from about 1000 mph at the equator to zero at the poles. This motion continuously changes the hot spot on the earth and churns the troposphere in six major zones, each with its prevailing wind motion. The height of the troposphere varies from about 11 miles in the tropics to about 5 miles at the poles. Zone widths vary with the season and the day. Churning through this complex pattern the air displays such dramatic effects as vicious tornadoes and the lofty 300-mph jet streams periodically girdling the earth in sinuous paths.



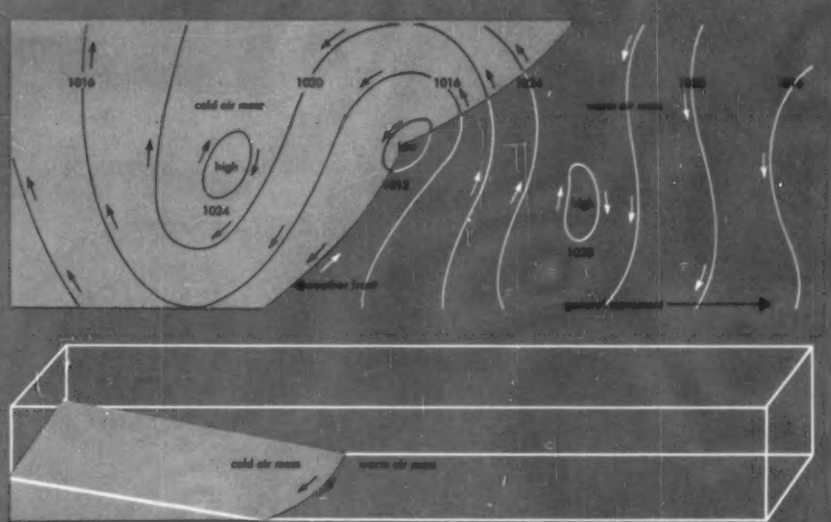


...and erratic, eddying movements in earth's thin skin of air...

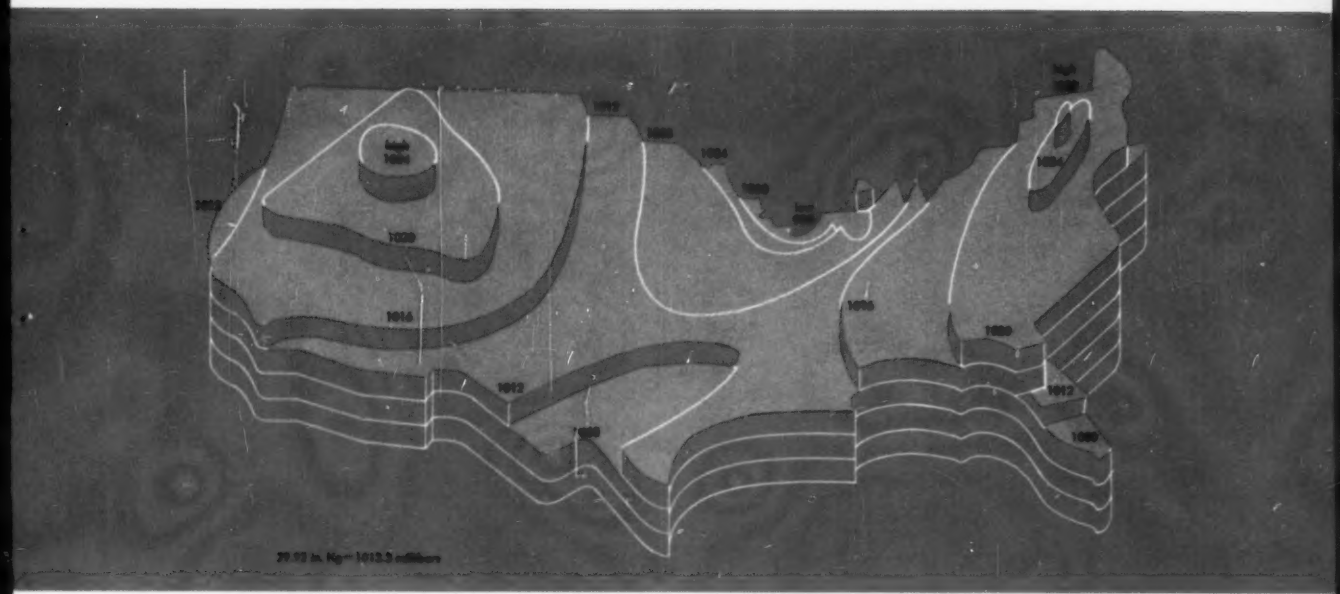
Air, being a gas, can move independently of the solid earth. When it moves with the earth we have a calm; when it moves in any other direction we have a wind. But the air has many unpredictable complex motions.

Great masses of air tend to move independently of each other—polar continental and maritime masses from the ends of the earth, tropical continental and maritime masses from the steaming torrid zone. As the accumulation of solar energy on the earth waxes and wanes these hot and cold masses battle for domination of the temperate latitudes. This gives us alternating fair and foul weather, while the occasional stalemates produce our enervating droughts or long dreary rains.

All weather depends on these world-wide forces, but local topography can sharply affect the prevailing climate, mitigating or worsening the general weather pattern.



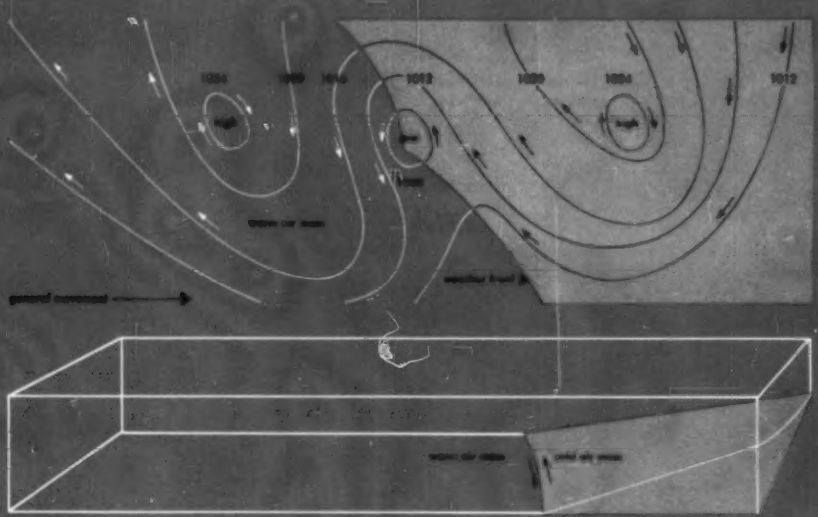
Advancing cold front has cold air mass from left wedging under warm air mass and lifting it. Above ground the wind flows around a low-pressure area, but on the ground the wind angles into the area and generally rises. Condensing moisture produces clouds and rain. Fronts form at margins of high-pressure areas or cells. Technically, air masses are high-pressure cells and they may be either warm or cold. They change their character as they travel world wide.



...whose manifold effects we feel and recognize as "weather"

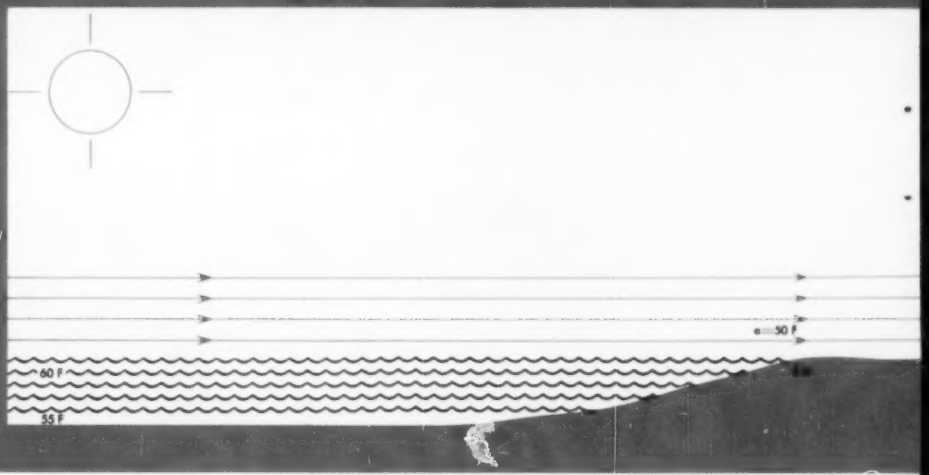
Battle lines of the air masses are set along the weather fronts. The results range from violent storms to just a mild change in temperature. Along the front will be a cyclone or low-pressure area with winds rotating counterclockwise around the center in the northern hemisphere. These winds generally rise at a much slower velocity. They bring in moisture, and rainy, windy weather prevails as the rising air cools and its vapor condenses.

On each side of the weather front will be high-pressure areas or anticyclones with winds moving clockwise about the center. The subsiding air brings welcome fair weather because the cold upper troposphere carries little water vapor, and the air warms as it slowly flows groundward, superheating any vapor that is entrained. Winds flow along lines of constant pressure at altitude, but at an angle along the ground because of frictional contact.



Advancing warm front has warm air mass from left overriding retreating cold air mass. Warm air being forced upward is cooled and its water vapor condenses to clouds and rain. Warm fronts usually move at about 15 mph, half the speed of cold fronts. Clouds may form as much as 1000 miles in advance of the ground position of a warm front. Sloping boundaries between warm and cold air masses form angles of less than two degrees with the surface of the earth.

As air sweeps across a vast ocean expanse it heats or cools and picks up a load of water vapor. As the wind sweeps on shore the sloping mountain side forces it to rise; the air cools and sheds most of its moisture load as rain. Tumbling down the far side, the dried wind heats faster than it initially cooled. Descending mountain winds rise and fall in waves in the valley and may form standing turbulent eddies. This depends on the changes in slope of the leeward side.

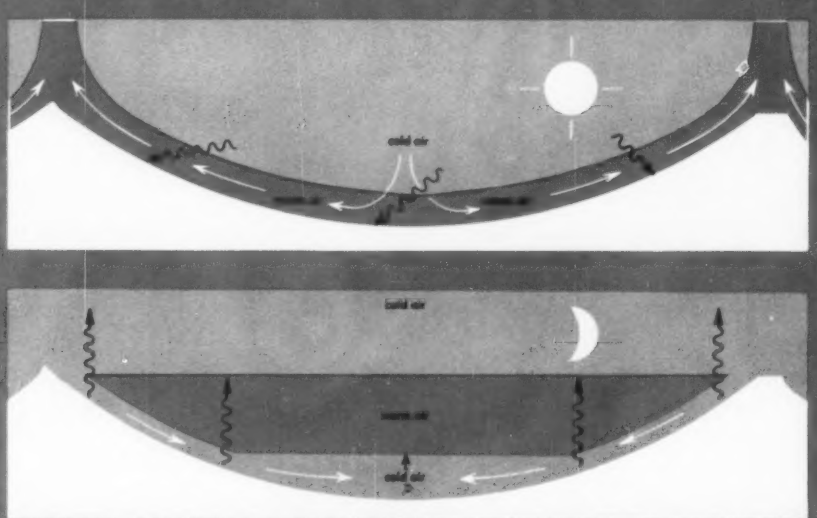


Land shapes and water expanses interplay with solar energy...

Widely varying water expanses over the face of our globe and topography of our land surfaces play important parts in forming regional climates. For instance, snow absorbs only 25% of incident solar energy, plowed fields about 80% and grassy fields and forests up to about 95%. Regions favoring cloud formation will stay warmer at night because the clouds absorb heat radiated by the ground. Clear nights are colder because heat radiates to outer space more easily with less vapor in the way.

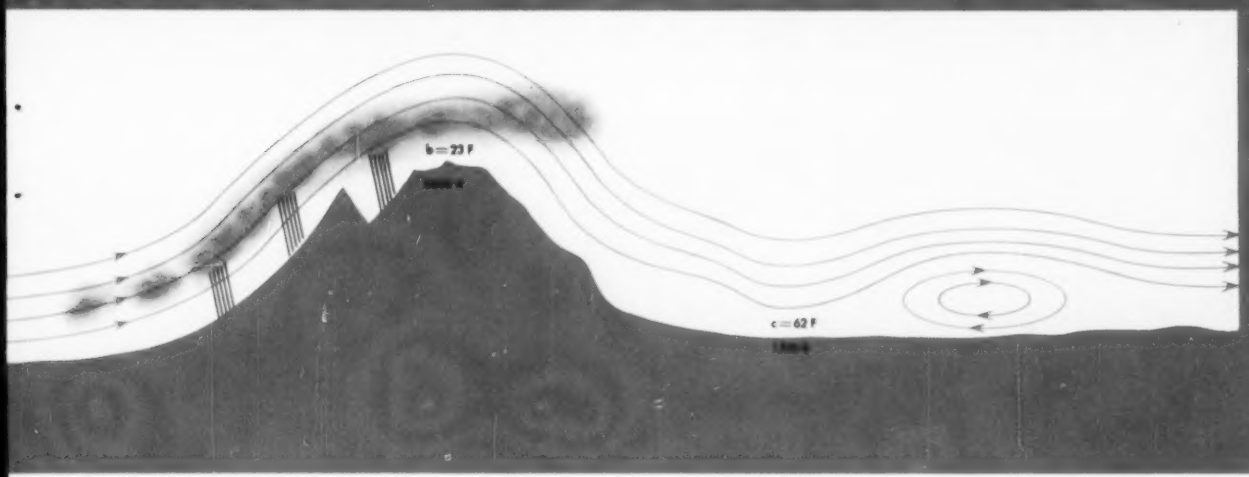
Mountains and barren ground bordering on green fertile fields or seas breed local winds moving contrary to the overall wind system of the globe. When these situations have broad enough geographic scope they can fix the climates of whole states.

Limited local situations are called *microclimates*—they show marked differences from the general regional cli-



On clear days the earth's surface heats rapidly and promptly warms the adjacent layer of air. Strong convection currents then flow up sloping surfaces. They induce colder upper air to subside into the valley, giving strong air circulation over the terrain.

On clear nights the earth's surface cools faster than the upper air and cools the lower air first. Cooled air flows downward and accumulates in valleys, causing stagnant inversions by trapping warm air above.

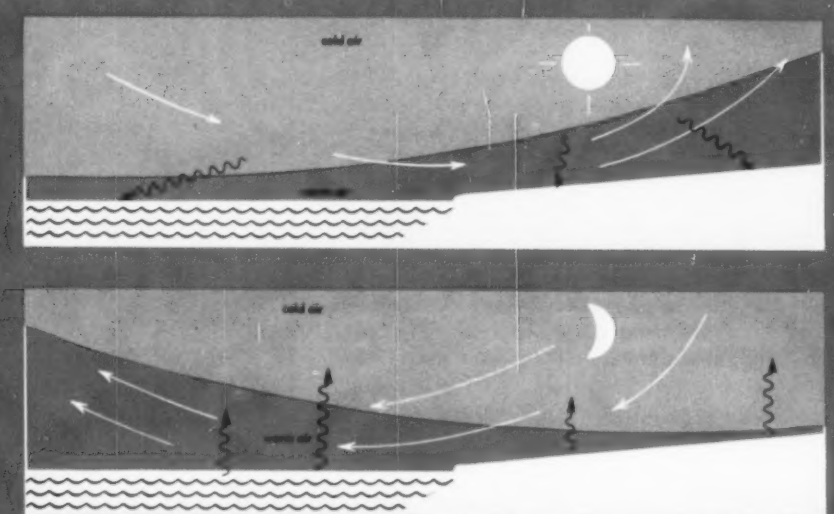


...to influence short-time changes in local weather conditions

mate. For example, Milwaukee on the windward shore of Lake Michigan has an average temperature 3.6-F lower than Grand Haven on the leeward shore during January, but 2-F higher in August. Milwaukee has 2-in. less rain from December to February but ½-in. more from June to August during the warm summer.

Forests stay warmer in winter than open lands but cooler in summer; winds don't blow as fast in forests, relative humidities and water storage are higher than in open land. Plants change microclimates by their varying use of water, the shade they cast, their effects on winds.

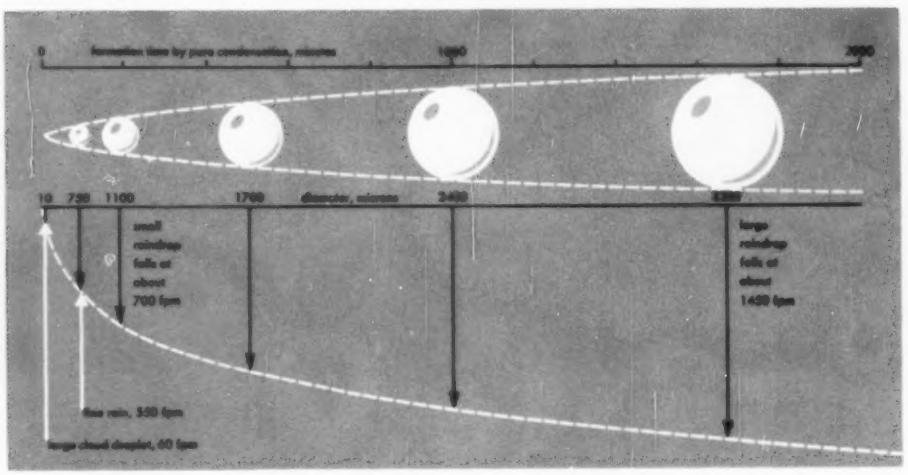
Coastal mountains, as above, control climates of the terrain they dominate. At *a*, we have sea winds at 50 F. They rise to 8600 ft at *b*, cool to 23 F. The falling wind then heats to 62 F at *c*, 1500 ft. (See lapse-rate diagram, fifth page of this report, for technical explanation.)

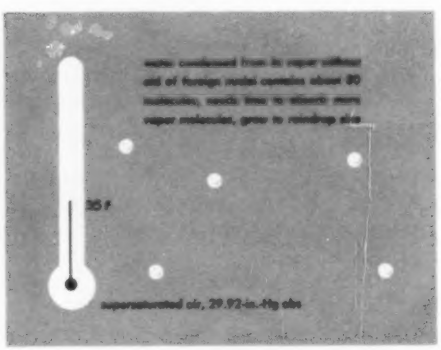


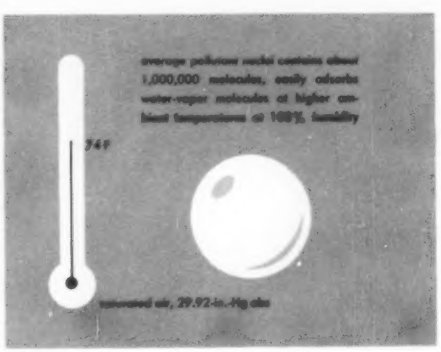
At the seashore on clear days the land usually heats faster than the water. The lowest air layer on land warms quickly, making the air unstable so that it rises. This induces an inland flow of cooler air from the sea, and sets up the well-known cooling sea breeze.

On clear nights the land cools faster than the water and so cools the low air layer on the land quickly. The heavier land air spills seaward where the lower air stays warmer longer, setting up a land breeze.

Airborne particles speed the rate of rain formation



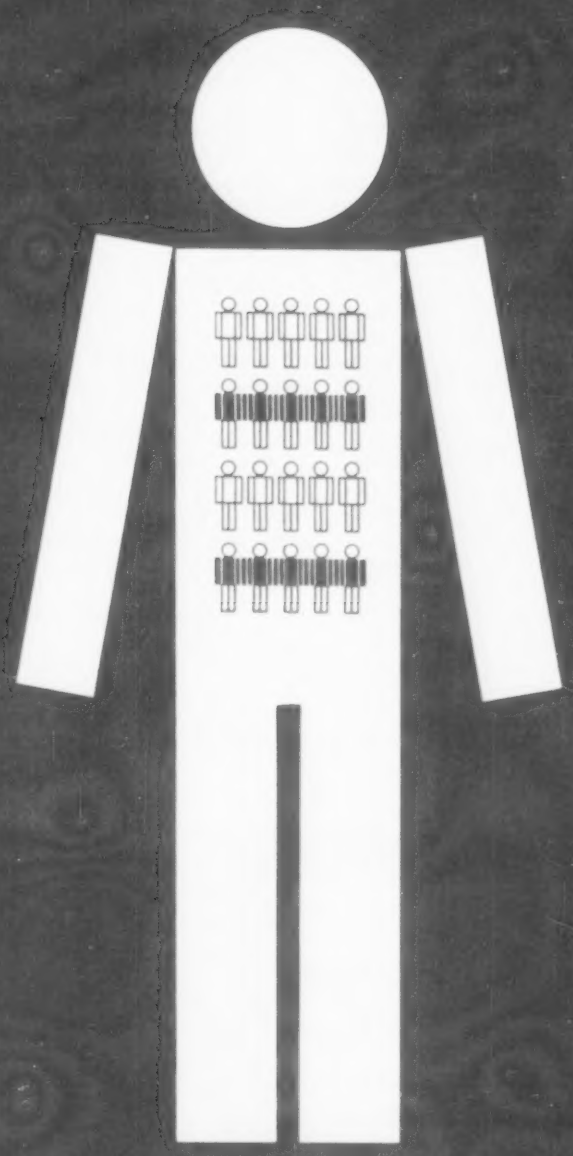




It takes time for raindrops to be born in the misty swirling interiors of the lofty clouds. Mixed air and water molecules dart about swiftly and collide with each other. Air molecules far outnumber the water molecules, tend to keep them apart, prevent them from agglomerating to grow to full-fledged raindrops. But when molecular motion slows down in the process we call "cooling," chances of vapor molecules agglomerating increase. Then condensation takes place at supersaturation, at temperatures lower than the normal level, left, to form water.

Polluting particles are much bigger than the individual vapor molecules. They move more slowly and form ideal gathering places that quickly adsorb water, lower left. They speed rain formation from the pedestrian pace shown in the graph above, and at much-higher temperatures, at or near 100% humidity.

Cloud droplets are tiny. They fall freely at about 60 fpm, above. But prevailing updrafts of air molecules keep them suspended. Large raindrops may stay suspended in violent updrafts; then a sudden change in air motion causes a cloudburst. So we see that nature makes use of various pollutants in its vast thirst-quenching water cycle.



Man and pollution: The day John Doe is born he starts polluting the air with every breath, cough, sneeze, even with the valeric acid found in human odors. As the years roll by his puffs of tobacco smoke, simple acts of cooking food, keeping warm, driving a car feed pollutants into our fresh-air supply. If John were a hermit this would be of little concern. Problems arise when many Does gather in communities to carry on the day-to-day chores of living, playing, working.

This concentration of Does increases pollution volume by sheer growth in numbers while, in effect, it creates a widely varying pollution pattern across the country. Then atop these joint offerings of man and plant being sent skyward the sun steps in, converting the base pollutants into still other and often more-harmful materials. This is the picture as it stands today, with the seriousness varying from region to region.

Pollution problems begin when activities become complex...

During the 1959 World Series a heavy cloud hung over the Los Angeles Coliseum—a cloud created in part by smoke from cigarettes, pipes and cigars being puffed by some 100,000 fans watching the Chicago White Sox battle the Los Angeles Dodgers. Perhaps many more smokers in number were watching and listening to the same game in their homes, without any observable effect on countryside air pollution. This is but one example of how John Doe's day-to-day pollution offerings to the air above us go unnoticed until he joins his fellows in community living.

In the larger urban areas of our country we find millions of people crammed onto relatively few acres. Even our once sparsely settled suburban sections are taking on a closer-knit appearance. Sum effect of this trend toward group living is further multiplication and concentration of the polluted outpourings of a single John Doe.

Home heating can be a major pollutant source. Products of combustion from the home furnace will vary widely in their effect on the pollutant tally, depending on fuel used, the design and condition of firing equipment.

Gas as a fuel for domestic space and water heating generally produces little significant air contamination. But oil burning adds oxides of nitrogen and sulfur in sizeable doses in addition to some organic materials. Coal-burning home and apartment-house heating furnaces can be a major source of air pollution, even in an industrial city. Solids, oxides of nitrogen and sulfur, organic materials are high in the exhaust from bituminous-coal fires. And the finger of control points to all these components as air pollution continues to increase in severity.

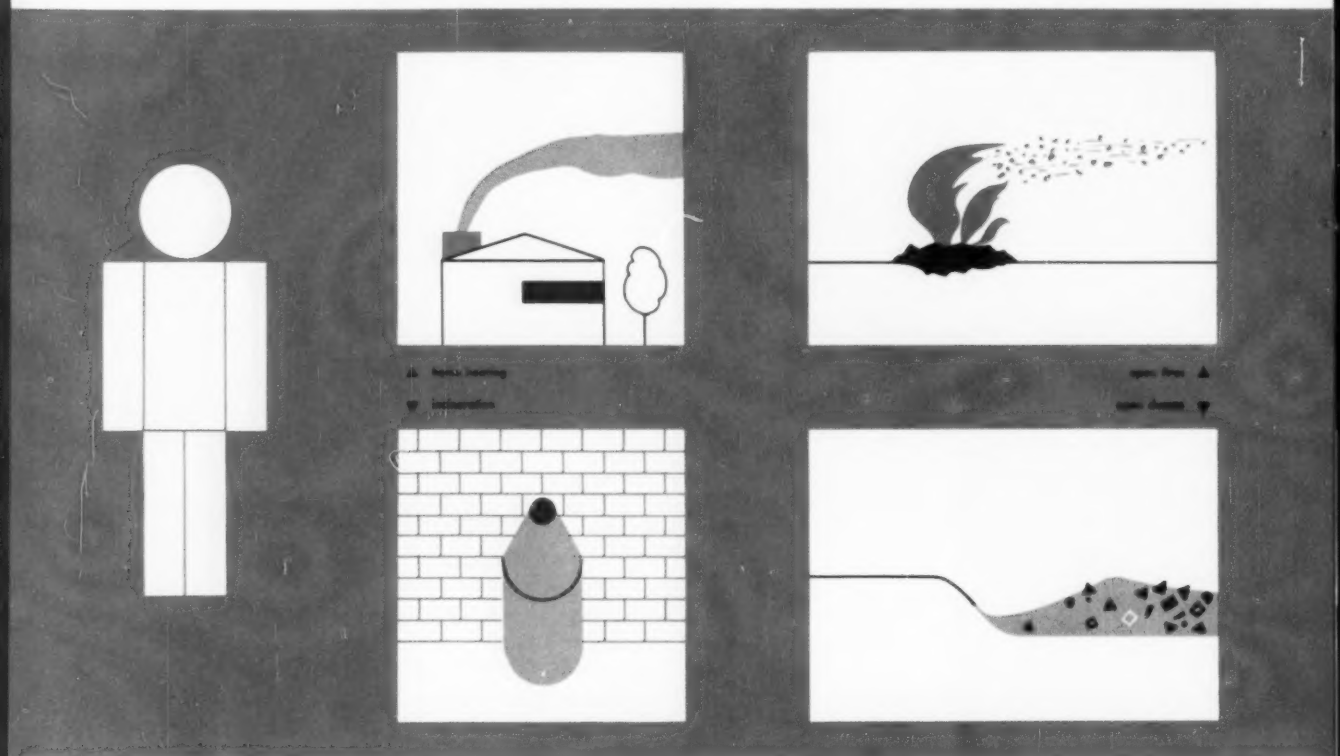
To get some idea of relative quantities, let's look at the chimney exhausts from 100,000 homes. If all burned an average grade of bituminous coal, some 307,000 lb per day of pollutants would be formed. Of this total about 200,000 lb would be solids, 42,000 lb in the form of SO_2 and SO_3; organics would account for 20,000 lb and about 30,000 lb would be organic acids.

If the same 100,000 homes burned oil you could expect 42,000 lb of combustion products to be given off. This total would consist of 17,000 lb of SO_2 and SO_3 and 12,000 lb of organic acids along with lesser amounts of still other pollutants. If gas were the fuel, these same 100,000 homes would produce a mere 10 lb per day. Electric home heating, with its zero pollutant output, may be one answer for polluted regions where gas isn't available.

Domestic incineration by household units may be another big offender. For a time all household incinerators were banned in Los Angeles, Detroit, Pittsburgh and Philadelphia because of NO and other solids spewed forth.

Older units, made up of a single furnace with gas-fired grate, were a serious problem. Heat of combustion cooked off moisture and vapors from unburned garbage above the main flame. These, plus solid material carried over in the exiting flue gas, presented a significant problem.

Using our same 100,000 homes as a yardstick, domestic incinerators of the single-furnace design could produce



daily 12,000 lb of organics, 16,500 lb of solids, 8400 lb of aldehydes, 1900 lb of organic acids—a total of 40,000 lb every day for the housing group.

Newer version of the home incinerator has two chambers in series; the second completes combustion of the gaseous material while trapping solid particles.

Open burning, including backyard burning rigs, often represents the second-largest pollutant source in an area. Many communities just do not have adequate refuse collection, forcing residents to burn paper, leaves and assorted debris in backyard bonfires, again pouring forth sizeable quantities of organics and solids.

Open dumps are a nuisance primarily, since the main output is methane, not looked upon as a serious pollutant. But decaying vegetable matter poses an odor problem.

Exhaust fumes from the ever-swelling hordes of autos, buses and trucks have certainly become a major headache to several metropolitan areas—perhaps John Doe's biggest contribution. Recent survey of air conditions at several busy points in New York City showed 50-ppm CO—toxic threshold for continued exposure.

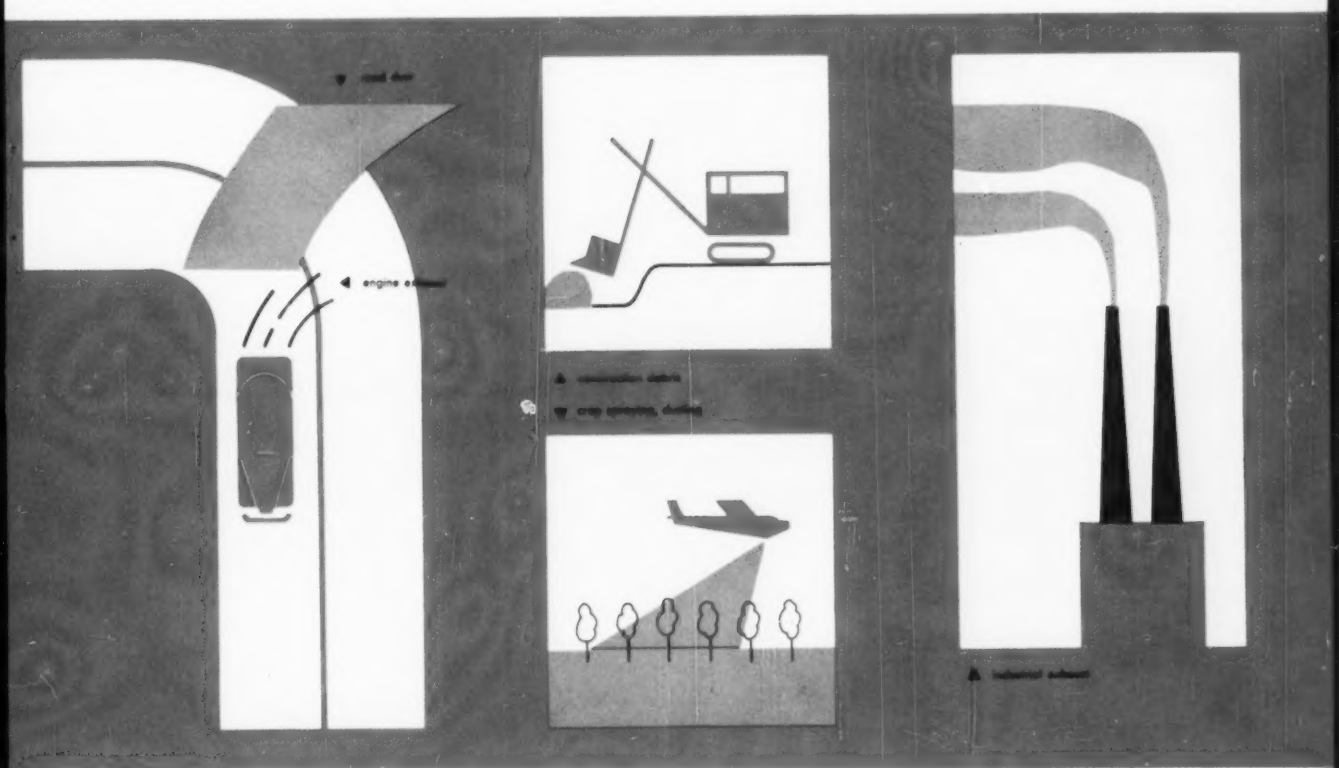
Striking example of serious exhaust pollution is found in Los Angeles County. Every day about 7-million residents drive 3-million cars and trucks, consuming 6-million gallons of gasoline and diesel fuel. Combustion of the gigantic volume of petroleum creates 9600 tons of CO, hydrocarbons weighing 1000 tons, 300 tons of NO plus smaller quantities of aldehydes, SO_2 and other products.

Road dust kicked up by man and his vehicles is another contributor to the pollution total. Each year tons of rubber particles are deposited on highways along with pulverized concrete, cinders, sand and dirt. Usually most of this material stays close by, remaining a localized source of pollution. Solution to this problem will be a long time coming since any wheeled vehicle will abrade rubber and crush other solid particles into dust. Perhaps tomorrow's levacars—those windy vehicles riding on a cushion of air—will cut back highway pulverizing. Since road dust is classed by many as a secondary source of pollution, it will get little serious attention in the immediate future.

Construction of buildings and roads is often accompanied by an all-too-obvious haze testifying to particulate matter being churned up. In the growth areas of larger cities, continued demolition and rebuilding of multistory buildings creates an almost permanent haze. It's impossible to lick this source completely, but much dust could be avoided by wetting down debris and maintaining cleaner conditions on construction sites. One consolation in our control failure: results are not smog-forming.

Crop dusting or spraying is akin to construction dust, from a pollution standpoint, since aerosols and dusts are deliberately made airborne. Selective application and careful attention to weather conditions will help.

These are the main air-pollutant byproducts of John Doe's community life. But to compound the problem, we have industry—one big reason for John Doe's city living.



Basic industrial processes, such as evaporation, attrition...

Man's industrial complex is the most-obvious contributor to air pollution, although not necessarily the most serious. Industrial pollutants take three forms: visible particulate matter—smoke and dust; nontoxic odors, which are a nuisance factor; toxic and irritating vapors—CO, SO_2, nitrogen oxides. Of the three, visible smoke and offensive odors will draw public complaints since in the minds of many these alone constitute pollution. In contrast, the hard-to-detect invisible vapor may often go unnoticed although possibly a more-serious pollutant.

A practical way to classify industrial pollution is by source: noncombustive and combustive. The former, as discussed here, produces evaporated gases, attrition dust, particulate carryover, cooking vapors, reduction-process fumes. In various combinations we see these basic noncombustive mechanisms at work in about every industrial plant. Naturally, many factors govern the quantity of pollution from each source.

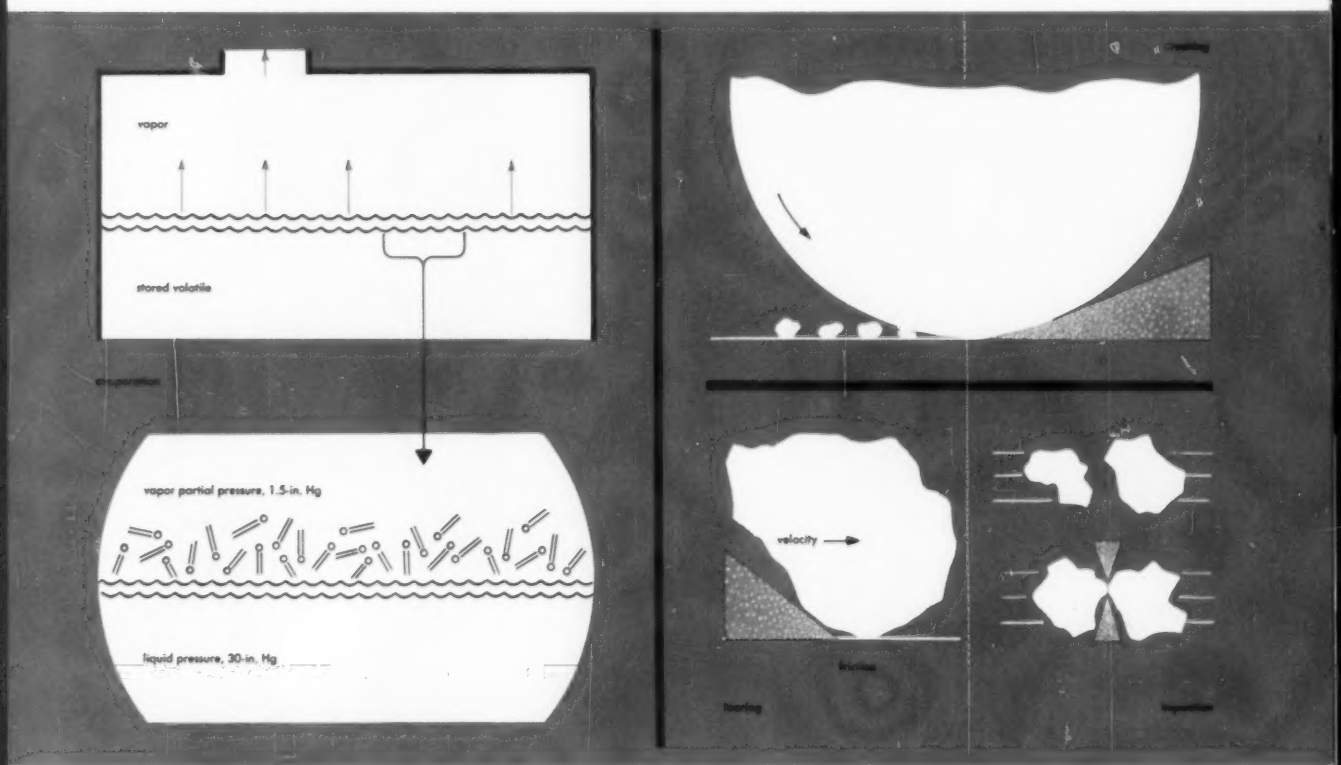
Material evaporation is a continual pollution challenge for several industries. Take petroleum as an example. Problem appears first at wellhead where gases and light ends cook off storage tanks and other oil-field equipment.

Refining crude petroleum into marketable products needs high-temperature and high-pressure processes. The necessary storage tanks, furnaces, boilers, reactors, pumps, lines and valves permit evaporation wherever leaks occur and in any areas where vapor-producing spaces are permitted. In Los Angeles County alone, it is estimated that 50 tons of hydrocarbons per day are released skyward from crude-oil production, even with present restrictions.

To understand the driving force behind evaporation one must know something about the physical characteristics of the liquid involved. Look upon any liquid as a molecular mixture, drawing, left. With these molecules in constant motion, some are bound to reach a temperature and energy level permitting them to break through the surface film. In effect, these escapees have reached a boiling point. As with most processes, this molecular transfer takes place on a 2-way street with some molecules continually re-entering the liquid. But during evaporation most traffic is outward. When does evaporation stop? Not until the partial pressure of vapor equals the saturation pressure for the vapor space temperature. In brief, the requirements for pollution by evaporation: (1) liquid has a high-enough energy level to permit change of state (2) space is available for the released material.

Attrition dust stems directly from grinding, polishing, pulverizing, screening, classification. Look upon the pollution offerings of these many manufacturing processes as industrial counterparts of nature's dust-producing ways.

Attrition normally takes one of three forms: crushing, impaction, frictional tearing, below. Crushing requires enough force behind the crusher to crumble any solid material in its path. Impaction, on the other hand, requires high velocity to supply the kinetic energy needed to break particles. Friction may be defined as the force opposing



...melting and chemical reactions create a variety of pollutants

relative movement of two surfaces in contact. The result of friction is wear and comes about from the tearing apart and gouging of minute "hills" which exist on even the most polished surfaces. In all three cases, sufficient force must be applied to the solid to break bonds holding it together. Sources are myriad, existing wherever solid particles are in motion and come in contact.

Provision is generally made throughout industry to trap products of deliberate attrition. But an equally important source of dust, unintentional attrition, is often overlooked. Handling dry solids is a case in point. Dust from coal or rock conveyors is particulate matter ranging in size from 1000 microns down to 1 micron. In most materials handling, all three types of attrition combine in varying degrees to produce fine pollution particles.

Belt conveyors, pneumatic-conveyor systems, solids-mixing equipment, outdoor coal-pile compacting all give off fine solid particles. But these fine products need not become a source of pollution. So long as dust is not thrown into the air or wind allowed to pick up the particles, no pollution problem can develop.

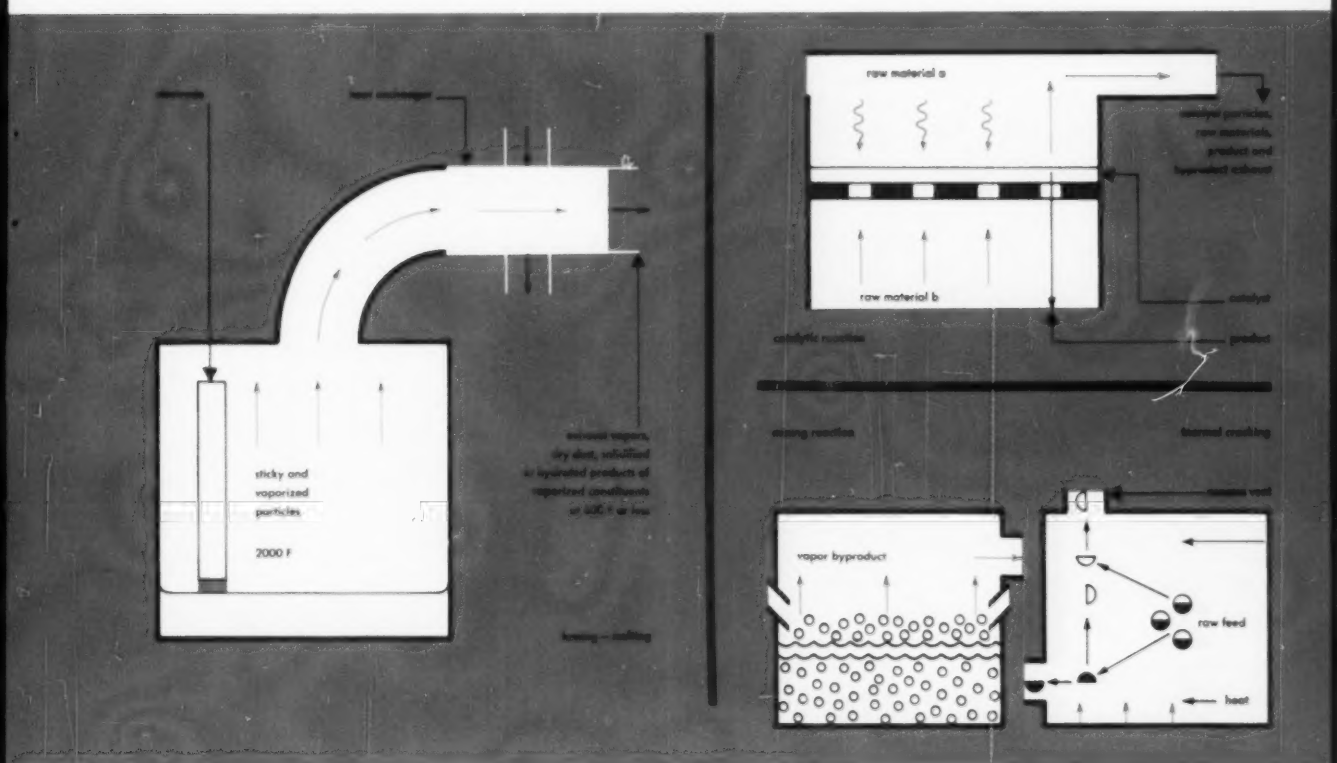
Melting materials introduces several new pollutant groupings. Their newness comes about because of the high temperatures necessary. Most furnace melting calls for mixing solids, then purifying by liquefying and driving off unwanted portions. Some of the unwanted constituents pass through the more-common steps of liquefying first, then gasifying on the way out. Others sublimate: jump directly to the gas state, then exit. Particulate pollution enters when some portion of the melted or gasified material returns to solid form, often as small particles which are carried out with the exit gases.

One big problem facing industry today, at least that segment involved in melting, is determining actual exhaust products and the conditions which create them. Research in the glass industry indicates exhaust products vary not with furnace load but as a function of temperature.

Process reactions pollute the air as an effect of chemical change. Here, raw materials are brought together and permitted to react in such a manner that one or more desired products result. This is somewhat of an oversimplification since in an actual process involving chemical reaction there is some reversibility and some formation of intermediate materials. Actually, the majority of pollutants come about as a result of the intermediate reactions or other relatively minor side reactions.

Thus, understanding the business of pollutant creation from process reactions requires knowledge of process equilibrium conditions, effect of the many operating upsets that can and do occur, reaction characteristics tending to create unwanted side reactions. Once you've pinpointed source of pollutants and conditions leading to formation, you've gone a long way toward actual curtailing.

On the pages that follow we outline the basic mechanical and chemical combinations favoring pollution formation in both the furnace and internal-combustion engine.



The complex process of furnace combustion may yield smoke...

Combustion processes create the largest single class of air pollutants, running the gamut from boiler flue gas and catalytic-reactor offerings to automobile exhausts.

How does combustion create pollutants? In the normal combustion process oxidation is the primary reaction. And in most cases the oxides are stable. But as in any chemical reaction, intermediate compounds and radicals form with all reactions reversible to some degree.

Theoretical combustion reactions always assume perfect conditions. These conditions are approached, but they're never reached in a practical combustion process. And perfect mixing does not occur. Then, when you consider that optimum pressure and temperature for burning may not exist long enough to complete primary reactions, it is apparent that exhaust gases will always carry some small percentage of the intermediate products formed.

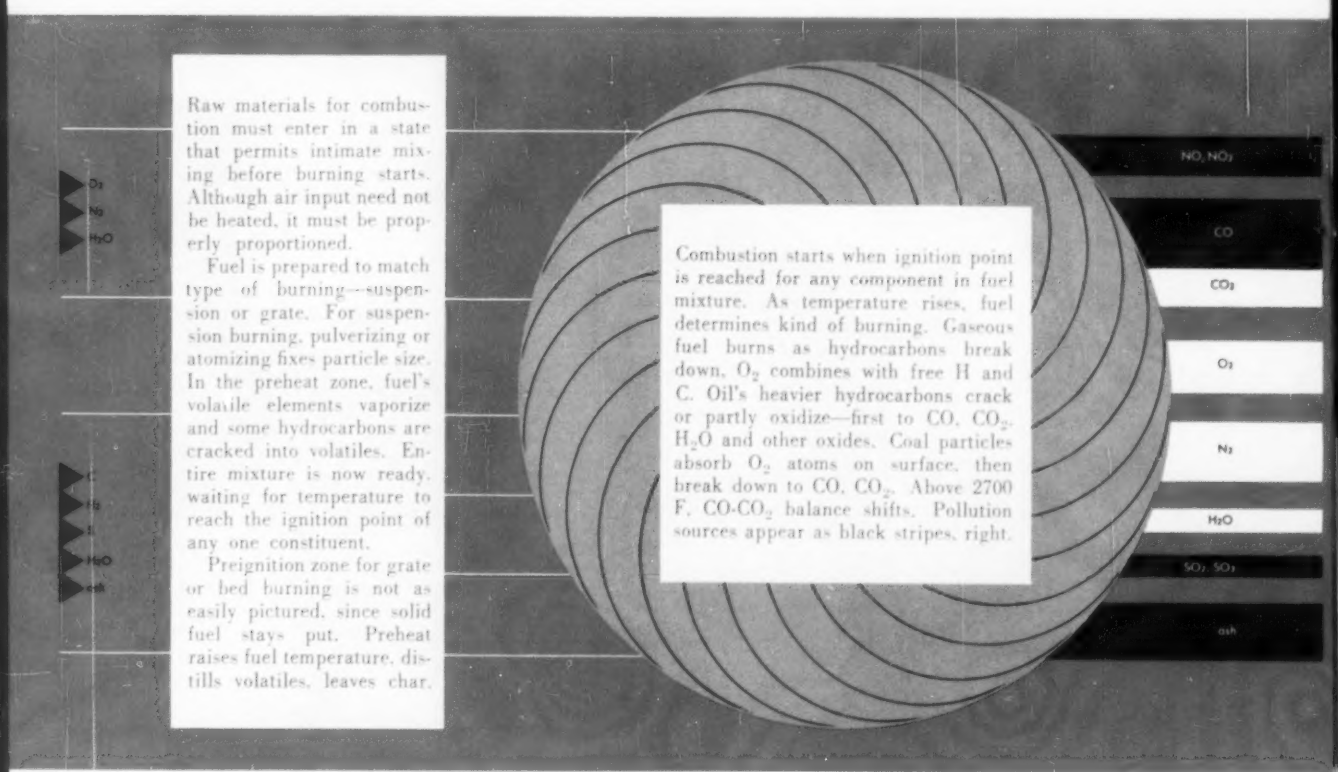
Symbolization of furnace combustion appears below. Raw products entering the furnace include combustion air and fuel. Incoming air needs no special preparation. But fuel must be in a form permitting maximum reaction rate for the type of burning equipment being used.

Combustion-zone reactions are not the cut-and-dried affairs we often think of. For example, a prime reaction in most furnace combustion is the oxidation of carbon: $C + O_2 \rightleftarrows CO_2$. In any actual process, however, there are two additional reactions: $2C + O_2 \rightleftarrows 2CO$ and $2CO + O_2 \rightleftarrows 2CO_2$.

Rate at which each of these reactions occurs is a function of temperature and the degree of mixing. Assuming for the moment that mixing is adequate, carbon oxidation follows two methods, depending on whether temperature is below 2200 F or above 2700 F. Below 2200 F, carbon particle's outer layer absorbs oxygen until saturated. Then outer molecules break off and combine with more oxygen to form approximately equal amounts of CO and CO_2. At 2200 F this absorption reaction has reached a maximum rate. Solubility of oxygen in carbon decreases rapidly above 2200 F with reaction rate approaching zero at 2400 F. At temperatures between 2400 and 2700 F there is no active oxidation. This 300-F span in effect is a dead zone through which reaction temperature rises at the start of combustion and drops again at the end of major burning.

Above 2700 F carbon and oxygen combine directly without prior absorption. In this temperature range oxidation produces about twice as much CO as CO_2 because of relative equilibrium coefficients for the extra reactions.

Combustion sequence then becomes: (1) Oxidation to equal parts of CO and CO_2 as reaction temperature climbs to 2400 F. (2) Very slow oxidation of the remaining carbon up to 2700 F with conversion of CO to CO_2 dependent upon the H_2 and H_2O content of gases at that time. Although H_2 reacts with oxygen more than twice as fast as CO, presence of raw H_2 or water speeds CO-to-CO_2 reaction. (3) Carbon oxidation continues after temperature drops below 2400 F. Burning of carbon and conversion to CO_2 slows down as reaction temperature drops


Raw materials for combustion must enter in a state that permits intimate mixing before burning starts. Although air input need not be heated, it must be properly proportioned.
Fuel is prepared to match type of burning—suspension or grate. For suspension burning, pulverizing or atomizing fixes particle size. In the preheat zone, fuel's volatile elements vaporize and some hydrocarbons are cracked into volatiles. Entire mixture is now ready, waiting for temperature to reach the ignition point of any one constituent.
Preignition zone for grate or bed burning is not as easily pictured, since solid fuel stays put. Preheat raises fuel temperature, distills volatiles, leaves char.
Combustion starts when ignition point is reached for any component in fuel mixture. As temperature rises, fuel determines kind of burning. Gaseous fuel burns as hydrocarbons break down, O_2 combines with free H and C. Oil's heavier hydrocarbons crack or partly oxidize—first to CO, CO_2, H_2O and other oxides. Coal particles absorb O_2 atoms on surface, then break down to CO, CO_2. Above 2700 F, CO-CO_2 balance shifts. Pollution sources appear as black stripes, right.
NO, NO2
CO
CO2
O2
N2
H2O
SO2, SO3
ash

...various vapors and gases, dust particles in a wide size range...

below 2200 F. Result: unburned carbon and much CO not converted to CO_2 show up as pollutants in exit gas.

Even total combustion can create pollution problems. What is considered normal good combustion usually results in small amounts of unburned carbon and insignificant traces of CO coupled with sulfur compounds and nitrogen oxides. Sulfur present in the input fuel converts to about 98% SO_2 and 2% SO_3 during normal combustion. In gaseous form these are ready to combine with water vapor in the flue gas or outside atmosphere to produce acids. Coal firing differs slightly: under somewhat special but generally possible conditions a large percentage of the sulfur stays in the ash.

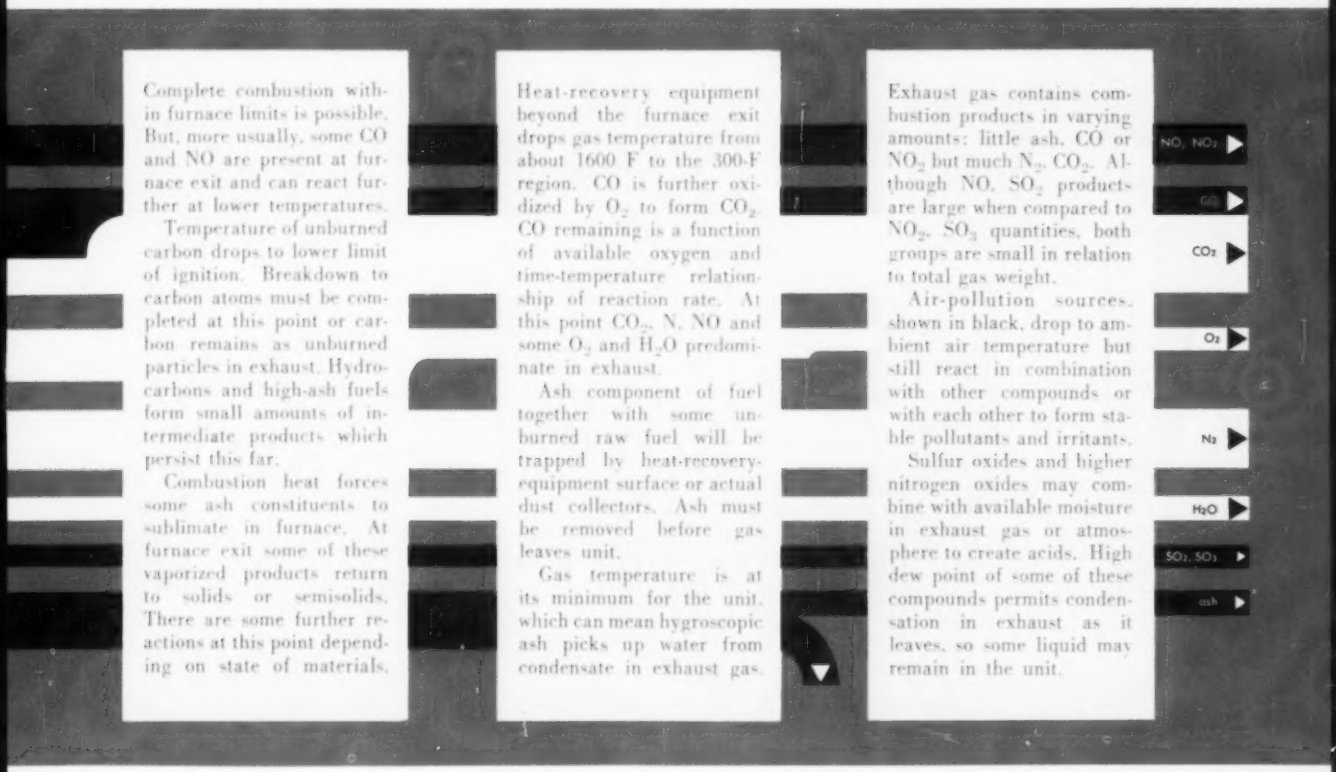
Nitrogen oxides form under conditions we usually think of as "perfect" combustion: good mixing, high gas temperature, adequate excess air. Until about five years ago little was known about nitrogen-oxide formation in furnace combustion. It was recognized that equilibrium constants are such that NO_2 cannot exist at the high temperatures met in a large furnace. But recent study of combustion-gas equilibrium at these high temperatures shows NO can exist at the elevated temperatures, actually increasing in concentration as gas temperatures keep climbing. In addition, the NO percentage increases along with excess air. NO is the primary nitrogen oxide since the high temperatures met in the furnace flame promote nitrogen fixation in combustion air: $N_2 + O_2 = 2NO$. At lower temperatures further oxidation forms NO_2.

Flue gas is still hot enough at stack temperatures to hold NO_2 to a minimum. Once the gas leaves the stack, atmospheric temperatures and an abundance of oxygen promote NO_2 formation. Furnace exit-gas temperature of 2000 F, followed by rapid relative cooling throughout remainder of unit, produces NO concentrations on the order of 0.1% or 1000 ppm. Converting to NO_2 in the air, this becomes a sizable quantity of pollution-producing gas.

After analyzing the effect of increasing temperature and excess air on NO production, consider the effect when these variables decrease. Naturally NO concentration drops with furnace temperature. But within the practical limits of stable ignition for a given unit, NO reduction is not great enough to do much good. Dropping combustion-air temperature 460 F decreases NO by only 50 ppm.

Reducing excess air, however, lowers NO concentration until the theoretical air level is reached. After that a further reduction, say to 95% theoretical air, cuts NO by the sizable chunk of 30%. Practically all NO formation takes place in a comparatively small high-temperature zone within a few feet of ignition point. So to limit air pollution by NO, remaining combustion air may be introduced just beyond this region. This keeps NO down while still completing combustion in the furnace proper.

This, in brief, is the story of basic combustion. Some pollutants form as a result of poor combustion, other more irritating ones are formed by good combustion. Now let's look at the internal-combustion engine.


Complete combustion within furnace limits is possible. But, more usually, some CO and NO are present at furnace exit and can react further at lower temperatures.
Temperature of unburned carbon drops to lower limit of ignition. Breakdown to carbon atoms must be completed at this point or carbon remains as unburned particles in exhaust. Hydrocarbons and high-ash fuels form small amounts of intermediate products which persist this far.
Combustion heat forces some ash constituents to sublimate in furnace. At furnace exit some of these vaporized products return to solids or semisolids. There are some further reactions at this point depending on state of materials.
Heat-recovery equipment beyond the furnace exit drops gas temperature from about 1600 F to the 300-F region. CO is further oxidized by O_2 to form CO_2. CO remaining is a function of available oxygen and time-temperature relationship of reaction rate. At this point CO_2, N, NO and some O_2 and H_2O predominate in exhaust.
Ash component of fuel together with some unburned raw fuel will be trapped by heat-recovery-equipment surface or actual dust collectors. Ash must be removed before gas leaves unit.
Gas temperature is at its minimum for the unit, which can mean hygroscopic ash picks up water from condensate in exhaust gas.
Exhaust gas contains combustion products in varying amounts: little ash, CO or NO_2 but much N_2, CO_2. Although NO, SO_2 products are large when compared to NO_2, SO_3 quantities, both groups are small in relation to total gas weight.
Air-pollution sources, shown in black, drop to ambient air temperature but still react in combination with other compounds or with each other to form stable pollutants and irritants.
Sulfur oxides and higher nitrogen oxides may combine with available moisture in exhaust gas or atmosphere to create acids. High dew point of some of these compounds permits condensation in exhaust as it leaves, so some liquid may remain in the unit.
NO, NO2
CO
CO2
O2
N2
H2O
SO2, SO3
ash

...while internal-combustion engines present special problems.

Although internal-combustion engines may not produce the dramatic effluent we see pouring from steel-mill furnaces, majority of the toxic or irritating pollutants in many areas of our country can be traced to the exhaust from automobiles, trucks, trains and aircraft.

These pollutants stem from the complex hydrocarbons used to fuel and lubricate millions of engines. Most of the products formed are not very different chemically from those of furnace combustion. Important distinction hails back to the three *T*'s of any combustion process—the particular *time, temperature, turbulence* factors inherent in gasoline, diesel and gas-turbine engines.

Even under ideal conditions, the internal-combustion engine cannot attain combustion efficiency of a large furnace, for several reasons. Fuel-air ratios vary widely with load, and acceleration and deceleration modify this ratio. Also, temperatures are lower.

Between unbalanced fuel-air ratio and lower combustion temperature, engine's exhaust gases include sizable amounts of pollutants. Chief constituents of these gases on a volume basis: CO_2, CO and water vapor. But chief culprits in the smog dilemma are the volumetrically much-lower concentrations of unburned or partially burned hydrocarbons and nitrogen oxides. Relative concentration of either pollutant varies with engine operation.

When you're accelerating or cruising in your auto, NO concentrations run about 1000 to 3500 ppm. Conversely, highest hydrocarbon concentrations appear in deceleration exhaust. During deceleration a high vacuum exists in the cylinders so efficient burning is almost impossible, and hydrocarbons run 4000 to 12,000 ppm.

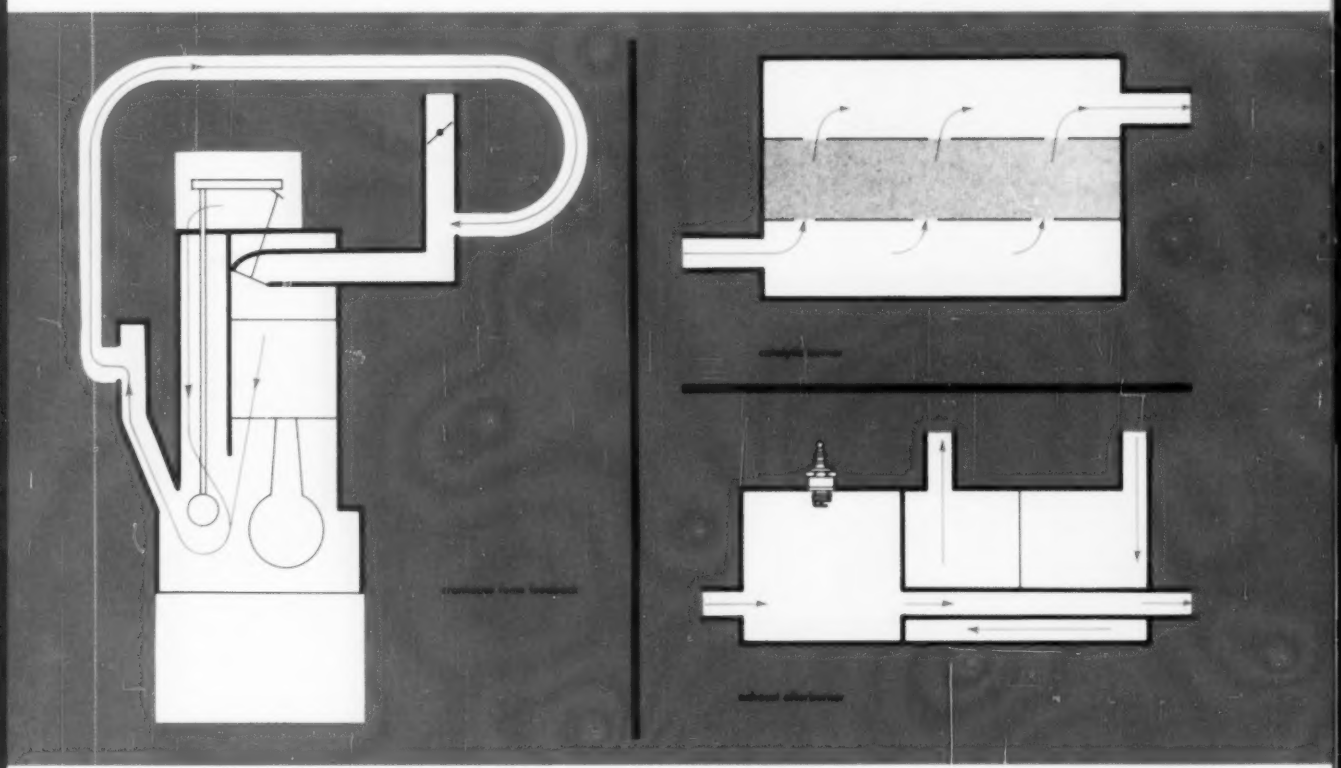
Diesel exhaust presents much the same problem. Having an extremely sharp combustion-efficiency curve, the diesel engine produces exhaust smoke with variations in speed. Gear shifting will not totally eliminate the smoking since most trucks do not have sufficient gear ratios to permit engine operation at constant peak efficiency.

Aircraft engines create most of their pollution during takeoff. Once the plane is airborne pollutants are diluted through a wider area, so they're a very minor source of ground-level contamination. But in the immediate range of a municipal airport, aircraft can be a real problem.

One final source of hydrocarbon exhaust can be traced to the engine lubrication system, below left. Evaporated lube oil and cylinder blowby accumulate in the crankcase and are ejected through the crankcase vent. Just how big a problem this is depends on the condition of piston rings and the amount of stop-and-go driving. In the aggregate, emission of this hydrocarbon contaminant can add up to 30% of all i-c-engine pollution.

Solutions to both these engine exhaust problems are under way. The hunt for answers follows these tacks:

Designers are shifting crankcase exhaust vents from simple open-ending to a feedback. New engines return crankcase vapors through a vacuum valve, back to downstream side of carburetor. Recycling burns hydrocarbons



To make matters worse, some pollutants are changed by sun rays

in the cylinders, dropping overall pollution by 30%.

One tail-pipe-exhaust solution would require complicated throttle controls to shut off fuel input during deceleration. More-popular plan calls for use of catalytic burners or afterburners to rid exhaust of hydrocarbons. But to date the catalytic approach poses a life problem because of poisoning by fuel's lead compounds. And the afterburner needs more work on stability and temperature transients which occur during stop-and-go driving.

I-c-engine exhaust, in combination with many other pollutants described on previous pages, becomes a major problem when these constituents react to form smog. This smog comes about when a combination of natural and man-made pollutants reacts under very specific conditions. The actual pollutant composition will vary from one community to another. In one, particulate matter may be the major factor. In another, internal-combustion-engine exhausts are the big problem. In a third, sulfur compounds and CO will be the chief concern.

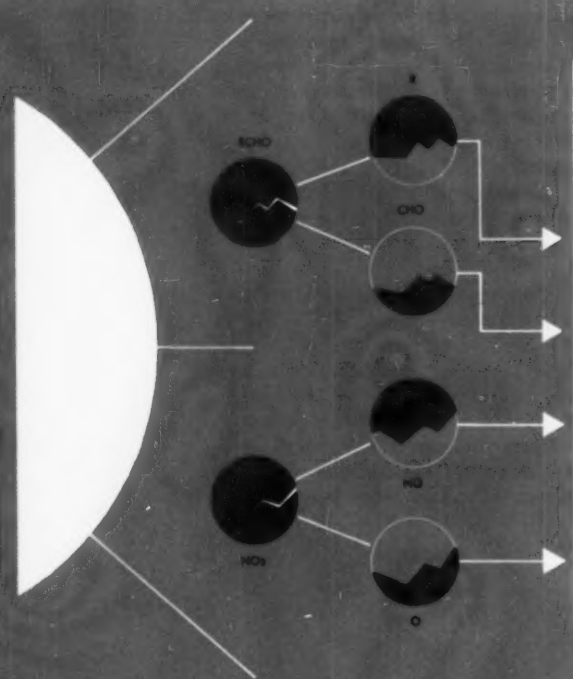
For certain sections of the country, local weather, working with NO and hydrocarbons, tends to boil up a mess of annoying smog. Here raw pollutants thrown into the air are acted upon by the sun; result is further changes. In the photochemical reaction the raw pollutants absorb solar energy, changing their makeup.

Primary photochemical reactions, shown below, involve decomposition of NO_2 and various olefin hydrocarbons by solar radiation. Apparently the olefin-series compounds are the only important hydrocarbons involved. Tests show that paraffin-series compounds do not enter into smog formation to any significant degree. In the photochemical reaction oxygen as O, O_2 and O_3 is needed in addition to NO_2 and olefin decomposition. Reactions outlined below show the important role oxygen plays in the overall photochemistry. For the most part free O combines with O_2 to form ozone. Only ½% of all available atomic oxygen enters into other reactions.

Molecular oxygen, O_2, further oxidizes $2CH_3$ and CHO radicals produced by olefin decomposition. At the same time ozone, O_3, enters into a series of reactions with NO, NO_2 and other oxides of nitrogen. Chain continues to N_2O_5 which combines with water vapor to create HNO_3.

All available evidence indicates that over most of the daylight hours in an urban atmosphere, NO_2 photolysis and NO - O_3 reactions mentioned above occur at much higher rates than any other known reaction involving the same substances. These reactions place severe limitations on the concentrations at which NO and O_3 can exist in air.

Studies carried out to determine the kinetics of ozone-olefin reactions and to identify reaction products show the list of reactions below to be of prime importance in smog formation. In addition to these, intermediate products including peracids, peroxides, hydroperoxides and free radicals appear. Much more work in this area is necessary before we fully understand these reactions. But we do know the prime ingredients: sun, time, exhaust.



Photochemical reactions change raw pollutants into smog. Basic ingredients are solar energy, NO_2 and olefin hydrocarbons such as ethylene or butylene. Latter materials decompose to NO, O, alkyls (R) plus formyl (CHO) radicals.

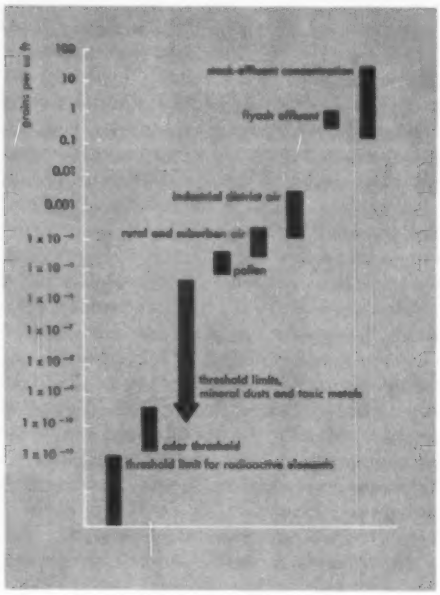
Olefins decompose to produce free alkyls such as CH_3 by absorbing solar radiation of 2500 to 5000 A wavelength. Single link available in alkyl hooks on oxygen to form other radicals—RO, ROO—or combines to form peroxides.

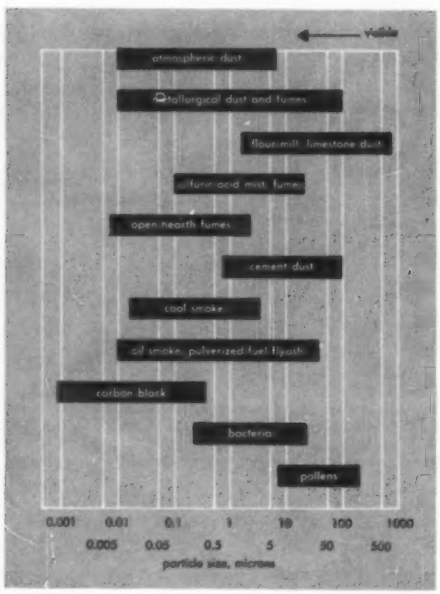
Formyl radicals (CHO) are extremely stable, but slowly decompose over long periods to H + CO. Subsequently H combines with O_2 to form water. In parallel reactions, CHO may combine with O_2 to form H_2O + CO or CHO_3.

Nitric oxide reacts with ozone and oxygen in many secondary ways: $NO + O_3 = NO_2 + O_2$, $NO_2 + O_3 = NO_3 + O_2$, $NO + NO_3 = 2NO_2$, $NO_2 + NO_3 \rightleftarrows N_2O_5$ (reversible reaction) and $N_2O_5 + H_2O = 2HNO_3$.

Oxygen in monatomic form will react with a number of substances known to be in urban air. But over 99.5% of all atoms react with O_2 to form ozone, O_3. Ozone reacts with NO and NO_2 to form compounds above, or with various hydrocarbons to form a family of oxides or more radicals.

Add it all up...and the problem can be severe





All the man-made pollutants discussed on the previous pages show up in varying amounts throughout the world. Our atmosphere will always be called upon to handle man's outpourings; it can take modest amounts without serious effect on mankind.

Trouble occurs when pollutant concentrations step beyond modest levels in the presence of adverse topography and meteorological conditions, as in Los Angeles today.

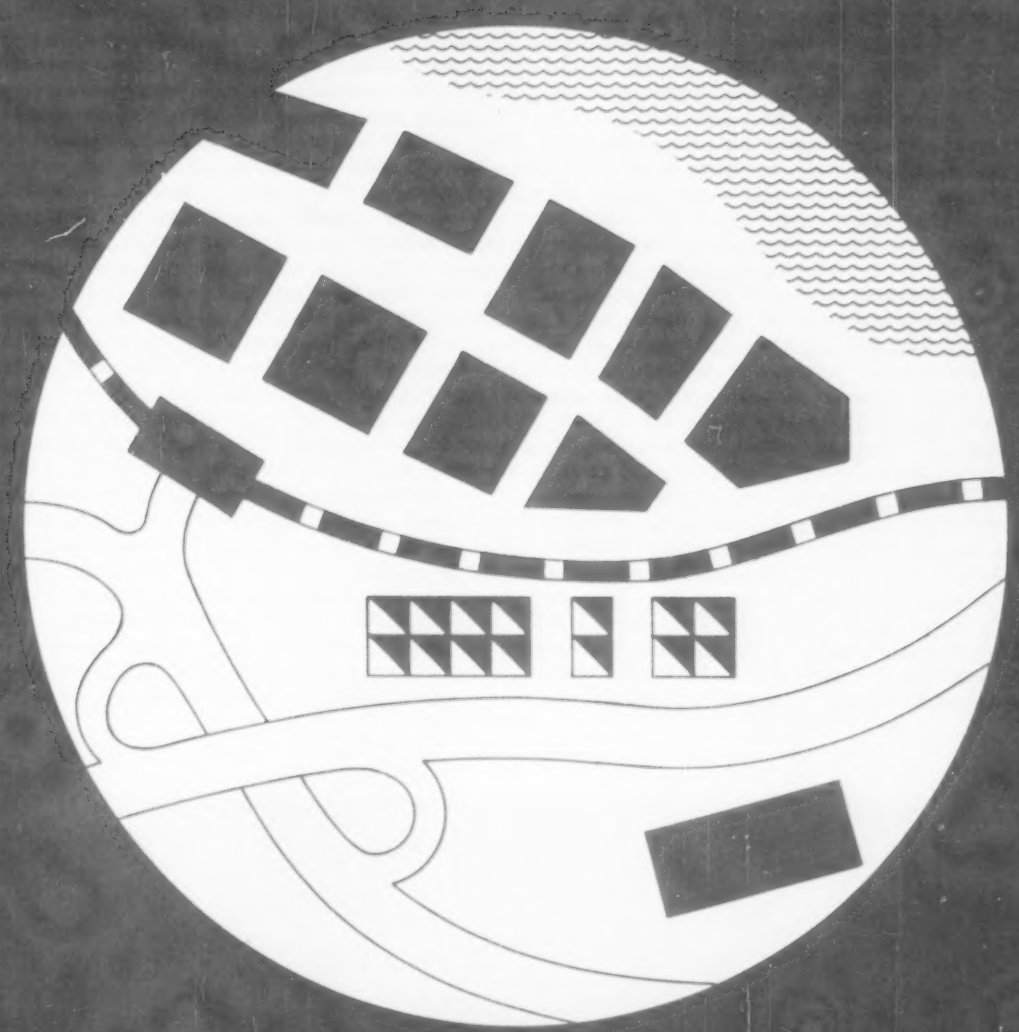
We started this section of the report by outlining the role John Doe and his fellow men play as pollutant contributors. Keep John in mind as prime contributor but give heed to the many other factors which must be present before his airborne offerings become an actual pollution problem.

First, outputs from a pollution source must accumulate, then geography and weather must act to prevent dissipation of the concentration. In some cases heat and sunlight must do their part by changing products through photochemistry. Of these many factors, the pollution source is the only area we can presently control. And, as pointed out in later pages, before we can intelligently attempt to control a source we must know what pollutants can be expected, their form—gas, suspended solids or liquid particles—particle size and total volume. This information can be determined by test sampling, estimates by experts familiar with the process, or applying average figures.

Pollutant density and particle size for several general industrial categories are shown at left. Remember these figures merely indicate ranges which can be expected under average conditions. They also show relative size and concentration compared to some natural air-pollution sources.

Up to this point we have outlined the nature of our planet's atmosphere, its natural pollutants and the mechanics of their transportation. We have also described how man makes his contributions to the overall problem. Now let's look at effects of air pollution on our social and economic existence.

C



Pollution and the community: In analyzing the many ways polluted air affects man and his community, we span the range from mild inconvenience to serious health hazard and on to a staggering out-of-pocket loss totaling billions annually. While we pay millions for research and control of the problem, this sum is but a fraction of what we are losing because efforts fall short of their mark. And unless more thought is given and action taken, these losses will continue to mount in the years ahead.

But what can be done by communities to meet this challenge effectively and economically? The answers are far from simple — but there are answers. First, every community's problem is highly individual. Each community must be carefully studied to find out the real pollution causes and most-practical solutions. Once the problem has been precisely defined and solutions indicated, then, and only then, can effective legislation be introduced.

Although evidence of pollutants' harm to man's health mounts...

The chart below typifies the range of air-pollution conditions to which man may be exposed during a year, month, week or even day. Pollution may be at the "nuisance" level, evident in a soiled white shirt, smarting eyes, etc. At certain times and places, concentration may reach "episode" levels, like those experienced in Donorra and London. Death may result for the aged and infirm if they're exposed long enough. City dwellers, in particular, are apt to spend some part of the time in the area between, where pollution is above the mere nuisance level. Actual curves vary widely, changing in time and degree for different groups and individuals in the groups.

Medical researchers are probing for answers not so much in any of these particular levels, but rather on the basis of *time-exposure*. In brief, they are attempting to integrate the area beneath the plot for varied groups over extended periods, then to compare the results of many such integrations with specific health problems showing up in the groups being observed. This is far from a simple problem since the pollution-concentration parameter must be well defined, both as to quality and quantity, and the many variables man himself presents evaluated.

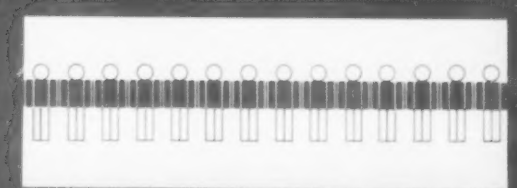
Some of this work has been done, but much more remains before we have definitive answers. Knowledge at hand indicates we can expect any significant damage to man's health to lie principally in the respiratory system. In fact, researchers in Great Britain have established beyond reasonable doubt that community air pollution is directly related to chronic bronchitis, a disease ranked third among causes of death in England and probably first among reasons for absenteeism. And then there is the rise in respiratory-cancer deaths, curves, next page.

What do we know about the link between respiratory cancer and air pollution? It's generally agreed that a number of pollutants found in community air will produce cancer in experimental animals. And we know that ozone and other irritant gases found in the air above us will scar animal lung tissues. Furthermore, such carcinogens—cancer producers—as benzpyrene are found in air.

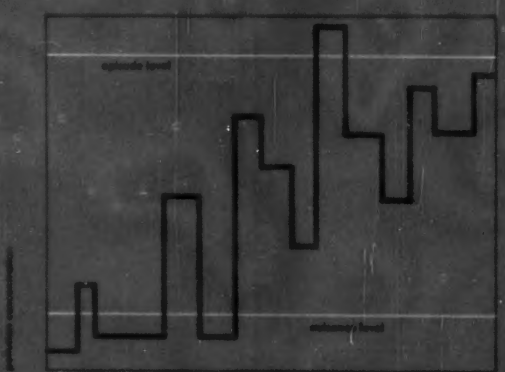
Benzpyrene is a hydrocarbon which finds its way into the atmosphere as a result of the distillation or combustion of fuels. Since it melts at 180 C and boils near 500 C, it generally exists in the atmosphere in the solid state. It is strongly suspected of being carcinogenic to man. Definitive proof is lacking, but there is evidence that human lungs remove this compound from soot, thereby permitting its eventual absorption into the body proper.

Test samples show concentration of benzpyrene is higher in the air above London than in most American cities. Nevertheless, sampling in 131 urban and rural areas throughout our country shows benzpyrene universally present. For most areas this hydrocarbon is at its highest level during winter months. If annual inhalation of benzpyrene is a measure of anything, the exposure is 100 times greater for a city dweller than a rural one.

According to the U.S. Public Health Service, sponsor



Air pollutants enter man's body in many ways: through the food he eats and the water he drinks; by surface contact, generally in form of eye irritants; by inhalation. Latter poses the biggest challenge today.



Man's travel through life brings him in contact with many levels of pollution. In a single day he might well be exposed to all the varying concentrations. Cumulative effect is chief concern of researchers.

. . . more research, especially on long-term effects, is needed . . .

of a continuing program of air-pollution study, there are many opinions among medical researchers as to which factor or combination of factors may play the leading role as a cancer-causing agent. Problems in evaluating harmful effects of air pollution are many. For instance, men performing heavy physical labor inhale deeper and more frequently; sex and individual size cause variations in respiration; smoking cigarettes, driving, even participation in outdoor activities are influential. Numerous studies indicate carcinogens have a cumulative effect.

Whatever the cause, we do know the death rate from respiratory cancer is highest in Great Britain. So using England and Wales as a base, let's examine the comparative health of emigrants who go to countries relatively free of air pollutants—South Africa and New Zealand.

In the case of South Africa, 44% more immigrant deaths were traced to lung cancer in the age group between 45 and 64 than among native-born South African males in the same age range. Remember South Africa has long been the world's largest consumer of cigarettes.

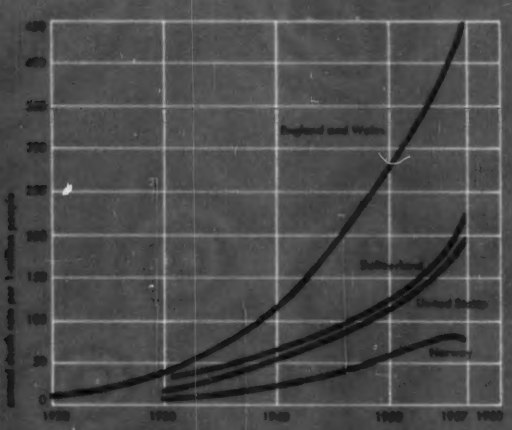
Massive 10-year study of emigrants to New Zealand points another accusing finger at air pollution. Here a quarter-million people who moved from the United Kingdom into the relatively unpolluted atmosphere of New Zealand provided the data. Two virtually identical populations were compared—the same heredity, essentially the same way of life, eating and smoking habits.

In this study, lung cancer was 30% higher among the newcomers generally than among New Zealand's native-born whites. Among Britons who went to New Zealand relatively late in life—first living in the U. K. 30 years or more—lung cancer was 75% over rate for natives.

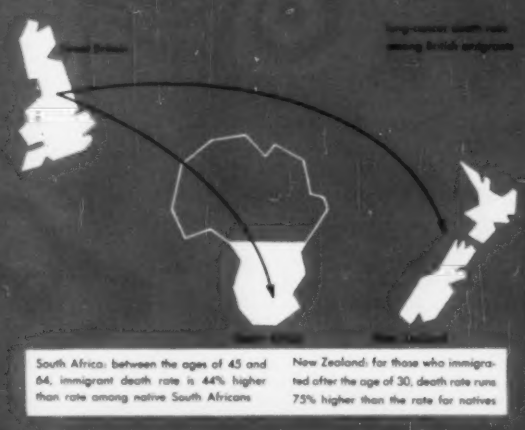
In addition to the other pollutants put into the air by man and nature, let us not overlook radioactive fallout. This is a distinct type of air pollution, consisting of tiny dust particles that persist so long in the upper atmosphere they actually diffuse from pole to pole. This delayed fallout takes place for years after large nuclear or thermonuclear explosions. It does not present the threat of sudden death—its effects, if any, would occur imperceptibly over many decades, perhaps many generations. Radioactive dust may settle on plant surfaces to be consumed with food or fall onto the soil where it's absorbed slowly by plant roots, thence eaten by animals.

What does it all add up to? Two things. First, there are at present gaping holes in our knowledge of pollutant effects on human health. Second—and serious long-range—we are not, as a group, emotionally prepared to act effectively on problems such as this one that seem remote in time. There is thus the risk that in waiting until the dangers are completely proved, we will delay too long.

The wise course would seem to be a parallel approach: (1) accelerated research on the effects of air pollution on human health and (2) increased attention to control programs based on the reasonable assumption that there *is* a relationship between air pollution and human health.



Real cause for steep increase in respiratory-cancer deaths is yet unknown. Many believe, and for sound reason, the answer may lie in our polluted air—including that portion self-induced by tobacco smoke.


South Africa: between the ages of 45 and 64, immigrant death rate is 44% higher than rate among native South Africans
New Zealand: for those who immigrated after the age of 30, death rate runs 75% higher than the rate for natives

Keeping Britain's high death rate from respiratory cancer in mind, above analysis sums up long-term effects when people emigrated from their highly polluted cities to cleaner areas of Africa, New Zealand.

. . . but dollar loss from unclean air is more readily apparent . . .

If we were to ask John Doe for a list of the many ways air pollution affects his pocketbook, he would probably point first to his soiled shirt collar or the laundry hanging on his clothesline that was smudged before it dried, or to his parked auto with its film of soot and dust.

He might well overlook his higher annual medical bills. Whether John suffers from a drippy sinus or a hacking cough, chances are the quality of his air input has some effect. He might also tend to skip over the cost of his annual chest X-ray—now considered a necessary trouble-detection measure, especially in polluted areas.

It's a sure bet he would fail to realize his personal efficiency is affected. But many high-school principals in southern California report a general student lethargy when smog is heavy. And controlled tests in telephone exchanges show operator alertness dropping as pollutants increase. What this loss in efficiency is costing American industry is impossible to measure. But the cost is there.

If John Doe were a farmer he would probably come up with more specific answers to our question. He might well have experienced out-of-pocket losses because of pollution damage to his livestock and crops. Perhaps his damage was only a small reduction in crop yields—or he may have been forced to market his products as second or third grade. But it cost him something.

There are many air contaminants harmful to vegetation: sulfur dioxide, hydrogen fluoride, chlorine, hydrogen chloride, nitrogen oxides, hydrogen sulfide and the sprays of weed killers, to mention a few. Damage will vary with the kind and quantity of pollutant. Symptoms: loss of healthy green color and discoloring of leaf undersides. During 1956, court cases in the United States because of losses on livestock and crops from the accumulation of one pollutant—fluorine—amounted to over $50 million. Some estimates place fluorine atop the list of air-pollution causes of agricultural loss.

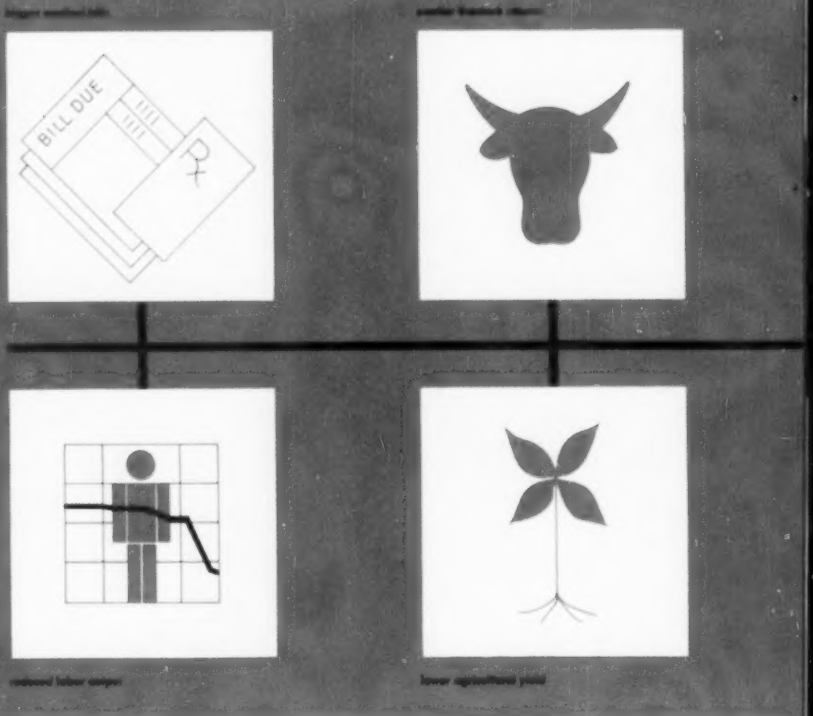
To the home owner, depressed property values are a continuing threat. It is not unusual to find $2000 cut from a home's value in a polluted area. St. Louis estimated, before air-pollution-control measures were enforced in 1941, property values had declined $25 million annually for 10 years. Another estimator puts a figure of $200 million as our present annual loss in real-estate values nationally because of air pollution.

Within the home the real culprits are fine particles that ride in with air currents when a door or window is opened. They settle on drapes, upholstery and carpets. They migrate to walls and ceilings where they cling and slowly accumulate as dark smudges. The fines make their way into clothes closets and into clothes being worn. Result is higher cleaning and painting bills. This soiling not only increases operating costs for the home owner but, in addition, proves a great burden to hospitals, hotels, office buildings, department stores.

Reduced visibility shows its effect in many ways, increased hours of artificial lighting being one. Many

Industry keeps laying out a sizable sum each year—at least $300 million—in the never-ending battle to reduce pollutant output from process and combustion sources. During 1960 the bill for air-pollution research ran to over $11 million. Of this total, our Federal government paid $5.2 million, industry $4 million; states and communities paid the remainder.

Even if we add to these figures the annual cost of maintaining pollution-control departments to enforce existing regulations, we are investing in the effort to do something about pollution only a fraction of the billions that pollution costs us annually. On economics alone, expanded research and control seem justified.



. . . running into billions annually, even with present controls

forms of transportation can be affected, notably the airlines. Nature is a frequent contributor to poor visibility, helping create London's smog (smoke-fog), New York's smaze (smoke-haze), El Paso's smust (smoke-dust).

By making a community unattractive to live and work in, air pollution can contribute to higher personnel costs. Employers may have to offer more to enlist top-grade people. Or they may have to settle for less-competent people than they would be able to engage if working and living conditions were fully satisfactory.

Within the industrial plant itself there are many ways polluted air, coming from outside the plant, increases costs. Some industries are more sensitive to airborne pollution than others. For instance, the paper industry is continually concerned about specks of dirt getting into a batch of white paper. The food industry is worried about odor pickup. Grit must be ruled out at all cost in a plant making precision rolling-contact bearings.

Pollutants that find their way into industrial lubricants are a source of headache for the lubrication engineer. To avoid them, costly care must be given to transferring lubes from oil-suppliers' sealed containers into bearings.

Equipment costs will rise somewhat when a machine is destined to operate in a polluted area—assuming you expect a trouble-free life span from it. Seals, paints and other protective finishes, perhaps the use of more-costly base materials, all add to the equipment bill.

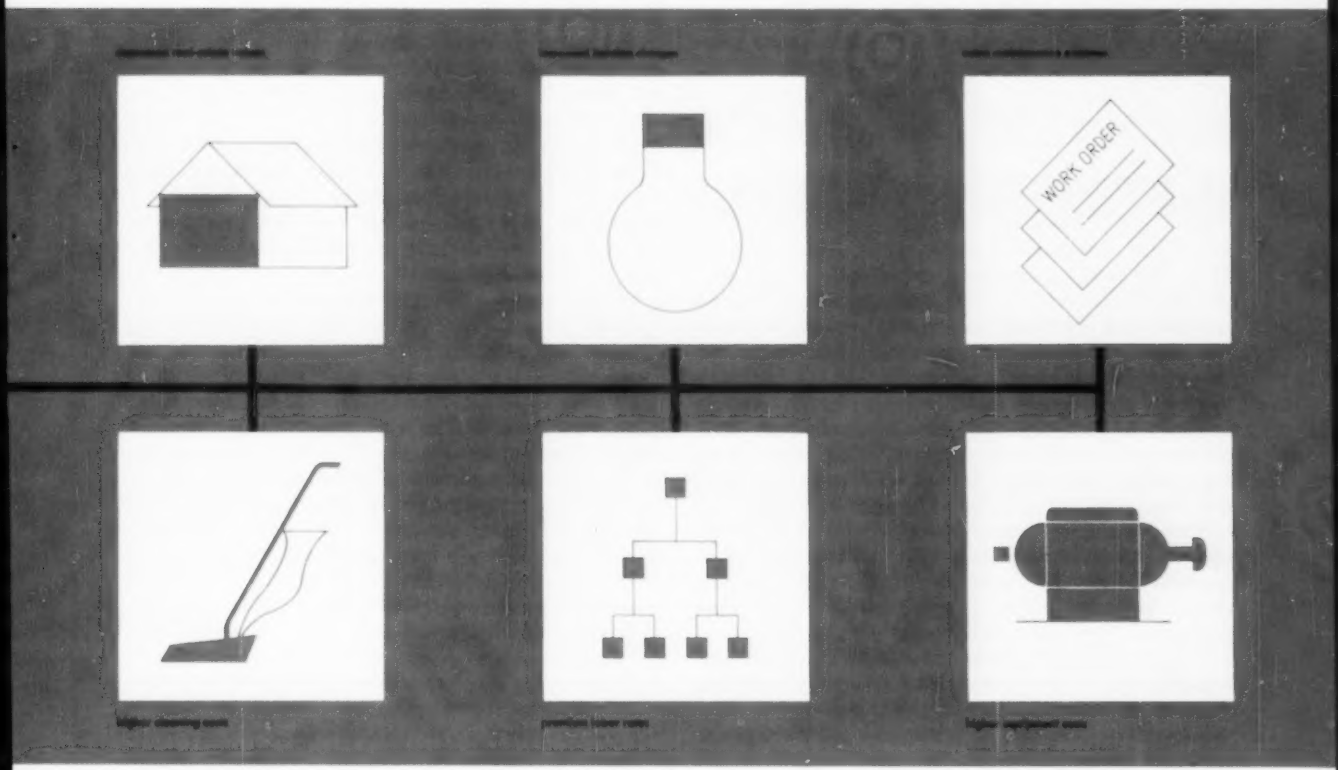
But if we want to put our finger on a single major source of economic damage to man and his community, it will be corrosion. Sulfur dioxide, a prime cause, comes into being as the result of combustion of sulfur-containing fuels. With oxygen present, sulfur dioxide is slowly converted to sulfur trioxide which in turn reacts with moisture in the air to form sulfuric acid.

Sulfuric acid, deposited by the air on metal portions of roofs, eaves, downspouts and a host of metal equipment, results in sizable losses from atmospheric corrosion. In New York City alone the annual bill for such corrosion is put at $6 million. Hydrogen fluoride, hydrogen chloride react with water vapor, forming corrosive droplets.

Salts in the form of ammonium sulfate and ammonium chloride are another pollutant source leading to corrosion. These are salts of a weak base and strong acid, so they hydrolize, yielding sulfuric acid and hydrochloric acid. Sodium chloride and calcium chloride are other salts of importance found more generally in seacoast communities.

Materials other than metals feel the effects of air pollutants. Consider building materials such as stone and masonry. Limestone may have its insoluble carbonates converted to soluble sulfates by acidic rainwater. Stone swells and surfaces peel off in flakes.

Textiles too are vulnerable. Remember the incident in Jacksonville, Fla. where one day women's nylon stockings literally fell into shreds? Leather is also attacked by sulfur dioxide. And the presence of ozone in the air tends to produce cracks in rubber tires and insulation.



In planning a control program, Central City U.S.A. first . . .

The growth of pollution potential

Air pollution promises to be a continuing problem in the years ahead. So long as man engages in social and industrial pursuits, it is impossible to have the relative purity in our atmosphere that would exist in a world without man. And as man increases his numbers, and as his standards of living climb higher, the results of masses and enterprises necessarily mean greater pollution potential.

What is being done about it?

As it stands today, air pollution's known effects range from relatively nil in some areas through "general dirtiness" in others to severe personal discomfort and property damage in still others. Efforts to combat effects appear to be substantially in direct proportion to degree of severity of the area's problem. In the main these efforts have taken the form of specific legislation to control what are believed to be major air-pollution sources. Some of this legislation is effective to a degree. Some is not and never can be for two main reasons: (1) Conceived and promulgated in what may be termed honest ignorance of the facts, legislation is unrealistic and may have punitive overtones. (2) Legislation is passed simply because "this is how Community 'X' handled the problem."

In some cases a community, vaguely aware that air-pollution difficulties may be in the offing, is reluctant to move to abate the problem because suspected pollution sources are vital to the economy of the area. Unsure how to proceed, the community does nothing. Such an attitude at best merely postpones, often aggravates a situation that inevitably must be faced and resolved.

What can be done?

What road should a community travel to reach a goal of effective air-pollution control? More important, what are the first steps that must be taken in setting foot down this road? First must come realization that the area is facing a "unique" situation. There is no such thing as a "typical" air-pollution problem—even though areas a thousand miles apart may contain similar pollution sources such as automobile exhaust or solid-fuels burning. Being unique, any given area's problem can be solved only through tailoring remedial procedures to fit.

Needed next is realization that with community growth comes an increase in air pollution. Our nation's population increase is pegged at about 14% by 1970, meaning a total of some 205 million persons. Our industrial output is expected to double. Because of today's population densities in metropolitan areas more than half of total air pollutants are released over a land area no larger than 1½% of the nation's whole. While it is true that cities will always be subjected to greater air-pollution potential than suburban areas, suburban potential will increase as time goes by. This means that consideration of air-pollution-control measures in many areas must go well beyond today's apparent needs.

Awareness by a community that control efforts should be instigated is meaningless unless the community clearly understands its problems and is determined that control costs be compatible with desired results. Understanding what the problem is may not be as easy as it sounds. Simplified, it means finding out what the pollutants are, where they come from and what harmful or undesirable effects they are producing. Broadly speaking, the path to such understanding is fraught with complexity and uncertainty, particularly concerning pollutant effects.

Get the help of experts

First step is collection and identification of pollutant samples. To a community totally unfamiliar with the enemy's face this can present a staggering obstacle. However, expert help is available. Today's cumulative wealth of experience in dealing with air-pollution problems around the world may be utilized by any who need it.

A hypothetical case: Central City wants an air pollution-control program. Its first need is competent technical advice. It turns, through its local and state Health Officers, to the U.S. Public Health Service with a request that facilities be provided to enable the community to coordinate activities and to develop a logical plan for air-pollution control. In taking this step Central City is availing itself of the provisions of Public Law 159, enacted by the 84th Congress and signed by President Eisenhower in 1955.

Central City's request will result in a thorough survey of its area under the supervision of the PHS. Cooperating in the survey will be citizens of Central City and members of its local government whose sole purpose at this point is to learn all they can about the immediate problem and how to take steps to control it. They are aware that the PHS has no law-enforcement authority and cannot engage in air-pollution-control activities.

PHS will direct and supervise studies of pollutants and their effects and give supplementary support, but the primary responsibility for administration of an air-pollution-control program belongs to agencies set up by local and state authorities. Exception to this rule: radioactive pollution caused by operations directly controlled by the Federal government and, if necessary, instances of interstate and international air pollution. Thus Central City becomes part of a gigantic and complex effort dedicated to erasing a menace.

Public Law 159 is a broad statute. It recognizes that air pollution may place health and welfare in jeopardy, harm agricultural crops and livestock, damage property, provide hazards to air and ground transportation. The law gives the Public Health Service a roomy field in which to roam in its search for causes, effects and the ways and means of possible control. It provides funds to help pay for research, study and testing by agencies at Federal, state and local levels and by private agencies.

industry and universities, to arrive at needed answers.

Too, the PHS has, through voluntary action of state and city governments, established the National Air Sampling Network to provide for systematic measurement of air pollution. Every one of our 50 states, as well as Puerto Rico, has at least one urban and one nonurban sampling station, each manned by state and local personnel. PHS provides the equipment, establishes procedures and analyzes collected samples. Good liaison throughout this far-flung complex of sampling, study and research means that if one group discovers something significant, other groups will learn about it quickly. Importantly, added coverage is being provided by a number of states who have established their own sampling networks.

Assemble all the facts

Central City's survey will let it move toward an effective control program based on intelligent correlation of cause and effect. A significant phase of the survey involves consideration of the area's meteorology and topography. These factors, perhaps more than any others, highlight the individuality of the local problem in that they tend to govern amount of atmospheric concentration or dispersion of wastes thrown into the air. Judicious planning which takes advantage of topography and air movements, such as controlling location of industrial operations with pollution potential, can have more real effect than restrictive legislation aimed in scatter-gun fashion.

Multitudinous samples are taken from the surrounding atmosphere under all conceivable conditions. Pollutants in these samples are subjected to exhaustive analyses to determine identity and quantity. Pollutant fallout patterns are studied and fallout quantities measured. So far as possible, pollution sources are located and their individual contributions plotted in proportion to the whole. In short, the survey produces *facts* without which any air-pollution-control program is apt to be worth little more than the proverbial snowball.

Study the findings

No survey is concluded overnight. Time is essential in which to cover all bases, correlate data, study the findings and consider methods likely to produce optimum benefit. Length of time necessary to conduct a survey depends, of course, on the magnitude of the problem. Cost, too, is important. Surveys can run into money, which means that careful planning is a must if Central City and its state are to get maximum return from the survey dollar.

Important factor in getting this return: emphasis on reducing lost motion in the survey operation. Much help in both planning the survey and interpreting collected data may be had by checking what has been done in other areas. Others have different problems, but Central City can often profit from their experiences.

Most air-pollution causes are relatively easy to define; many lend themselves readily to control, such as poor combustion or odor emission. Some causes, such as photochemical reaction in the atmosphere, fall into a gray area between cause and effect. From a practical standpoint, Central City's goal may be to reduce or eliminate emission of substances which permit such reaction to occur. But in the main, Central City's survey will produce a reasonably clear picture of its air-pollution *causes*. However, the *effects* of these causes range from the self-evident to far into the unknown, particularly where human and animal health is concerned. Some causes are suspected of having specific harmful effects, but to date there is no established proof. Effects other than those now known most certainly will be determined in time through unceasing research efforts around the world. When they are, air-pollution-control procedures in Central City will be flexible enough to be altered without difficulty because they're being planned that way.

Plan control approach carefully

Central City's immediate task is to apply what knowledge it has acquired to setting up the most effective counterattack. But there is much yet to be learned about the enemy, and much can be lost by a headlong charge. Too little is known about his overall threat to the citizens' well-being, and in planning his defeat, Central City must avoid the possibility of winning a Pyrrhic victory. Central City's plans must be made after full deliberation and with complete understanding and support of its industries and citizens whose livelihood will be affected.

Spell out the economics

Such understanding must be based on a clear picture of the economics involved in an effective air-pollution program. It's a matter of history that much progress has been made in controlling contaminants in milk, food, drugs, water and city wastes. Such progress comes only because enough people "cared" and were willing to pay for improvement. So it is with air pollution. However, this new menace does not tend to make its presence known as forceably upon the public as, say, poor-quality water.

It follows, then, that without public outcry and willingness to foot the bill little progress will be made in air-pollution control in any given area. In brief, people will get air-pollution control only so far as they are willing to pay for it. Further, an apathetic public may, in fact, be paying a price far out of proportion to the relief afforded by politically expedient "control" legislation.

So, as Central City's initial survey draws to its conclusion, accumulated data indicate the scope of its problem and study of procedures employed in other areas has brought an awareness of pitfalls and shortcomings of hasty and ill-advised control programs. Now the time has come for Central City to design its own control organization and methods based on what it has learned.

. . . then picked a qualified Board that acted with public support . . .

During the course of Central City's survey a Public Health Service Engineer from the Taft Engineering Center in Cincinnati supervised the operation. He met with officials of Central City and the state government, representatives of the chamber of commerce, various citizen groups and key industrialists in the area. The city's health officer arranged for other visits and inspection tours.

Helpful information poured in from the local U.S. Weather Bureau office. The PHS engineer then sat down with board of health representatives from city and state. Uppermost was the question: since evidence pointed out that control efforts should be made, what form should they take, what staff, budget, labs and laws would be required?

Based on analysis of all findings to date, he made several recommendations at that meeting. In brief: conduct a more-elaborate air-pollution survey, initiate a local control program, appoint a control board. Under the new board's guidance, the survey would check further into present pollution levels, nature and extent of pollution sources, meteorological pattern in the area. This study would be most valuable in planning control activities and evaluating accomplishments later. It would also serve well in laying out a land-use pattern, present and future. Before leaving, the PHS engineer reminded Central City officials of educational courses available at the Taft Center.

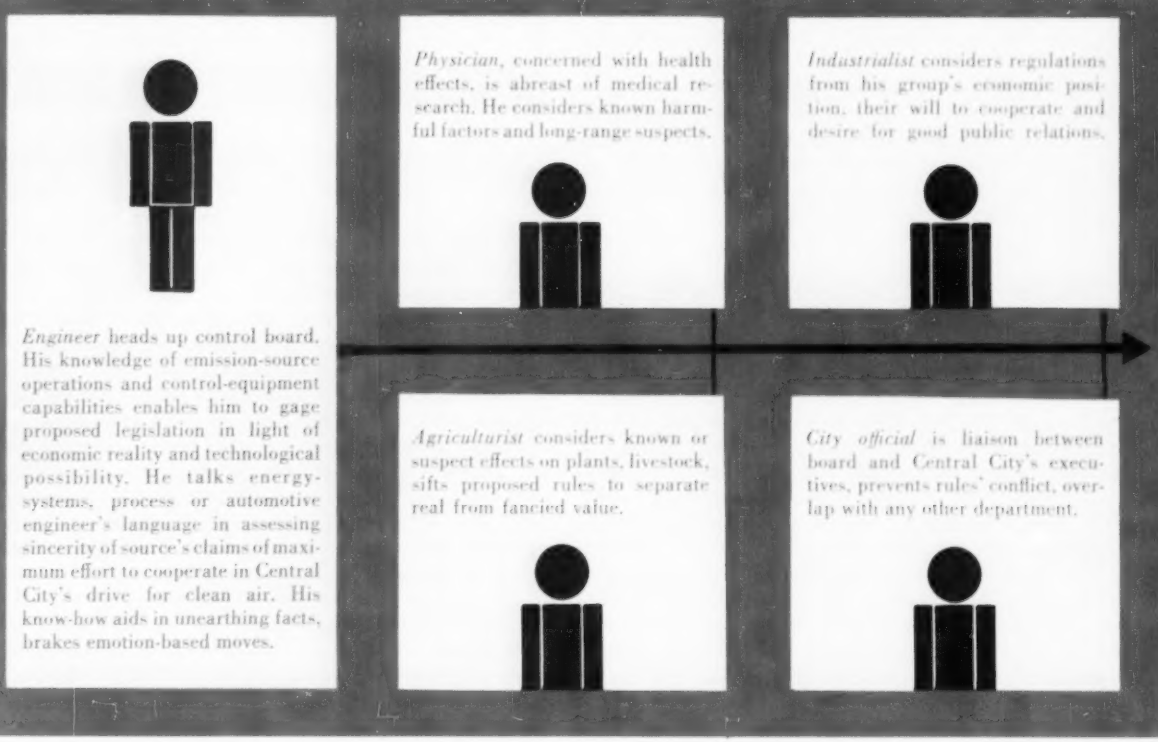
The recommendation to establish prompt local air-pollution control was made only after careful consideration. They felt little was to be gained from waiting for completion of the more-extensive survey, or of any outside research on air pollution then under way.

Central City's mayor, after consulting with state and city health boards, appointed a 5-member local air-pollution-control board. It was autonomous in nature and provided with adequate staff and budget. Headed by an engineer, the board's associate members were: a municipal official, a physician, representatives of agriculture and industry, see below. City council approved a resolution that the board's staff be selected via civil-service procedures. Staff would be headed by an air-pollution-control officer who would direct operation of enforcement procedures. Control officer and his men would be, in effect, Central City's air-pollution-control dept.

The air-pollution control officer, like the board's head, was chosen from the engineering profession. Reason: in pinning down causes, an engineer is a logical choice; he can identify specific pollutants, then classify them, if possible, in terms of sources. Too, his specialized knowledge is called into play judging both corrective and preventive equipment designs.

The a-p-control officer's prime function, aside from directing enforcement of regulations, would be to present the control board with specific factual evidence in connection with alleged violations. He would also present his recommendations on legislation proposed from any source.

The control board, on an equal-footing basis, would pool their background know-how in weighing the facts


Engineer heads up control board. His knowledge of emission-source operations and control-equipment capabilities enables him to gage proposed legislation in light of economic reality and technological possibility. He talks energy-systems, process or automotive engineer's language in assessing sincerity of source's claims of maximum effort to cooperate in Central City's drive for clean air. His know-how aids in unearthing facts, brakes emotion-based moves.
Physician, concerned with health effects, is abreast of medical research. He considers known harmful factors and long-range suspects.
Industrialist considers regulations from his group's economic position, their will to cooperate and desire for good public relations.
Agriculturist considers known or suspect effects on plants, livestock, sifts proposed rules to separate real from fancied value.
City official is liaison between board and Central City's executives, prevents rules' conflict, overlap with any other department.

and determining what proposed regulations should be sent to the city council with recommendation that they be enacted into law. The board would also devise emission-control regulations specifically for the local area. Such regulations would be based on investigation into degree of pollution complaints and on a survey of sources.

Furthermore, the board would strive to obtain compliance through education, inspection and enforcement of regulations. It would be fully aware that its most-important job is to find solutions at the overall or community level. From what it learned through study of other areas' procedures, the board would know that its best chance of achieving effective pollution abatement lies in using the preventive approach, not punitive actions which penalize for pollutant emission.

In approving the program, the city council realized the control board could not, in keeping with American tradition, function as prosecutor, judge and jury. Following this concept of "separation of powers," the city council stipulated that a separate and distinct appeals board be established to which an alleged violator might turn if he believed a regulation had not been interpreted in a fair and objective manner. If further appeal were desired, there would be provision for going to the courts.

Central City's 5-member air-pollution-control board then sat back and took stock. Though vested with considerable power and confronted with pollutant sources needing immediate corrective action, the board was not eager to start passing laws. They realized that attempting to control air pollution by forcing those causing it to cease operation would be tantamount to throwing the baby out with the bath water. Forcing an industry to clean up or shut down conceivably might be necessary in an extreme case. But such measures used with abandon would raise hob with the city's well-being.

Following the fundamental principle recognized by the Oregon legislature's air-pollution-control bill— "reasonable or natural use" of the atmosphere as a natural resource for waste disposal should be permitted—Central City's board knew that one of its first decisions would have to determine how much pollution is too much. They also knew there are no such things as standards of air-pollution control, that there are still too many variables and unknowns. This does not mean that air-pollution limits cannot be established in a specific area, so long as the limits are intelligently related to cause and effect. But arbitrary blanket requirements covering all emission sources, regardless of kind or character, would be highly impractical and economically prohibitive.

The board realized that Central City's people must understand pollution as a 2-way street. All suffer from pollution—but all contribute to it on occasion. The board's big job: impress upon the citizens that air-pollution control will be costly, but cost will tot up to far less than they are paying now, in one way or another, for letting polluted air continue in their community.

Central City's control board thus assembled represented a wealth of combined talent. Collectively they were well equipped to analyze situations involving regulations proposed to them by the control officer or by other sources. However, they were aware of other factors which could easily be overlooked while handling mechanical details of the proposals. And if these factors weren't considered, legislation might be enacted which would not be as effective as possible because it was not truly equitable.

First, they reasoned, industry and the individual have certain basic rights which must be considered. One such right is use of the atmosphere to carry off and harmlessly disperse a certain quantity of emitted wastes. No laws should prevent this natural resource from functioning usefully to its fullest capacity. Such a law could easily prevent industry or the individual from realizing technical, economic benefits. And of course, any tendency to abuse this right could readily be detected and corrected. The board believed that Central City's industry planning should be encouraged to take advantage of this factor when selecting plant sites. By using services offered by meteorologists in addition to those of consulting engineers, industry might provide itself with some natural "built-in" air-pollution controls.

Second, the board believed that regulations would ultimately prove unrealistic if they ignored the significance of equitable zoning laws. Historically, zoning laws protect residential areas against encroachment by industry but make no provision for the reciprocal. Investment in air-pollution-control equipment could be heavy. No industry should have this expenditure nullified by gradually approaching residential areas.

In keeping with this thinking on planned use of the atmosphere and common-sense approach to zoning laws, the board realized that legislation passed to meet Central City's apparent needs *at* the moment might well be archaic within a decade or two. And laws, once on the books, have marvelous staying power. Too, the board knew that "procedures" have a way of perpetuating themselves, that their successors would tend to follow precedents.

To set the stage for painless demise of outmoded regulations, the board made it mandatory that successive control boards review existing regulations at periodic intervals. Those found not effectively in step with the times *must* be revised or repealed at the future board's discretion. Thus by clothing future control boards with legal responsibility to keep pace with scientific and technological advances in air-pollution-control techniques, Central City's initial control board would perpetuate their philosophy of considerate, rational approach to the job.

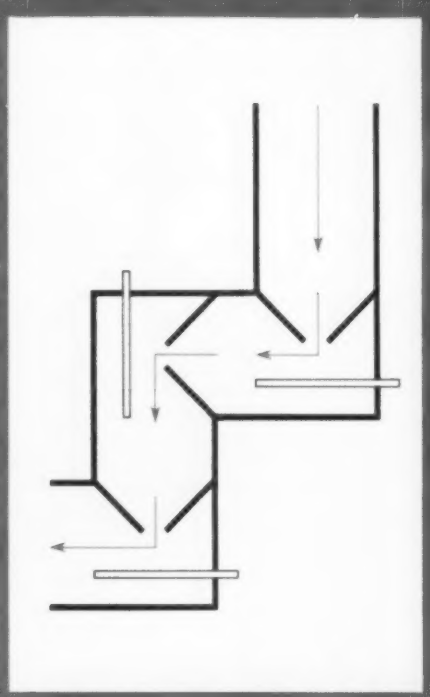
. . . establishing regulations that were definite yet flexible . . .

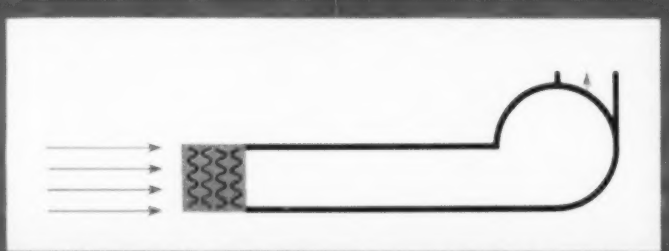
After more-thorough study and consultation with many outside experts on air-pollution control, Central City's board made its recommendations to City Council. In keeping with the desire for a strong local voice in control activities, and realizing that most problems deal with nuisances requiring equitable balance, City Council held a series of open hearings on the proposed control regulations. Both the board and city council recognized that the people of Central City should be the ones to decide what pollutants are objectionable and to what degree they should be controlled.

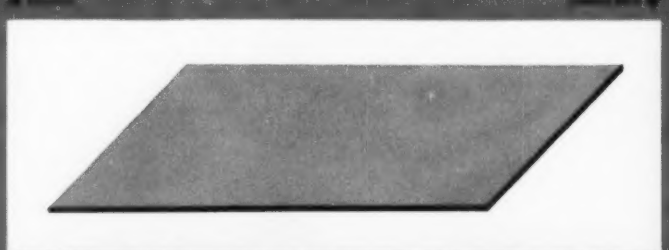
The community approved, and council passed a law defining illegal air pollution as: "emission into the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke or vapor, in quantities, of characteristics and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life or property." The law recognized that establishing concentration limits at emission sources as a blanket requirement would have little real value. Instead, contamination would be evaluated "in direct relation to its effect, at ground-level point of contact, on people, animals, vegetation and property." Such effects would be carefully assessed and corrective measures taken as found necessary to comply with the intent of the air-pollution-control law. Corrective measures would be weighed in the light of present understanding of effects of various pollutants. This, of course, ranges from the very self-evident to suspect effects for which there's no established proof.

The law indicated that it could and would be extremely firm with violators who willfully flout or flagrantly disregard the law's intent. It made provision for accidental violations and those of an extremely temporary nature. But, as written, the regulation contained no specific penalties for specific offenses, though it left the door open for future action of this sort at the discretion of the air-pollution-control board.

The board had recommended the basic law, as passed, because it believed that much could be done toward real control without punitive measures. First of all, realistically, they knew that the air-pollution-control officer would be faced with a gigantic task were it incumbent upon his department to ferret out each existing and new pollution source by field inspection alone. It would be practically impossible to staff the control department sufficiently to perform this function economically. Consequently, they had city council include a provision in the regulations to the effect that each existing and projected waste-emission source, above a specified minimum size, be registered by the owner in writing with the air-pollution-control department. Forms would be provided and required data would include (1) outlet's location (2) outlet's size (3) outlet's height above ground level (4) outlet's emission rate (5) composition or description of effluent and (6) description of effluent-cleansing equipment.







. . . *backed up with a continuous sampling plan to measure success*

In this regulation, the control board's thinking was that, regardless of what machinery was set up by government to administer air-pollution control, sole and immediate responsibility for holding the release of pollutants within tolerable limits must rest with the source-equipment owners and operators. This regulation, by placing responsibility on the alleged offender, recognized that he is best equipped to handle his particular problem and, with his own technical and engineering staff (plus available help from outside sources) can most economically design and install effective abatement equipment. Further, the regulation made it understood that the control department would not concern itself with process operations ahead of the effluent-cleaning equipment.

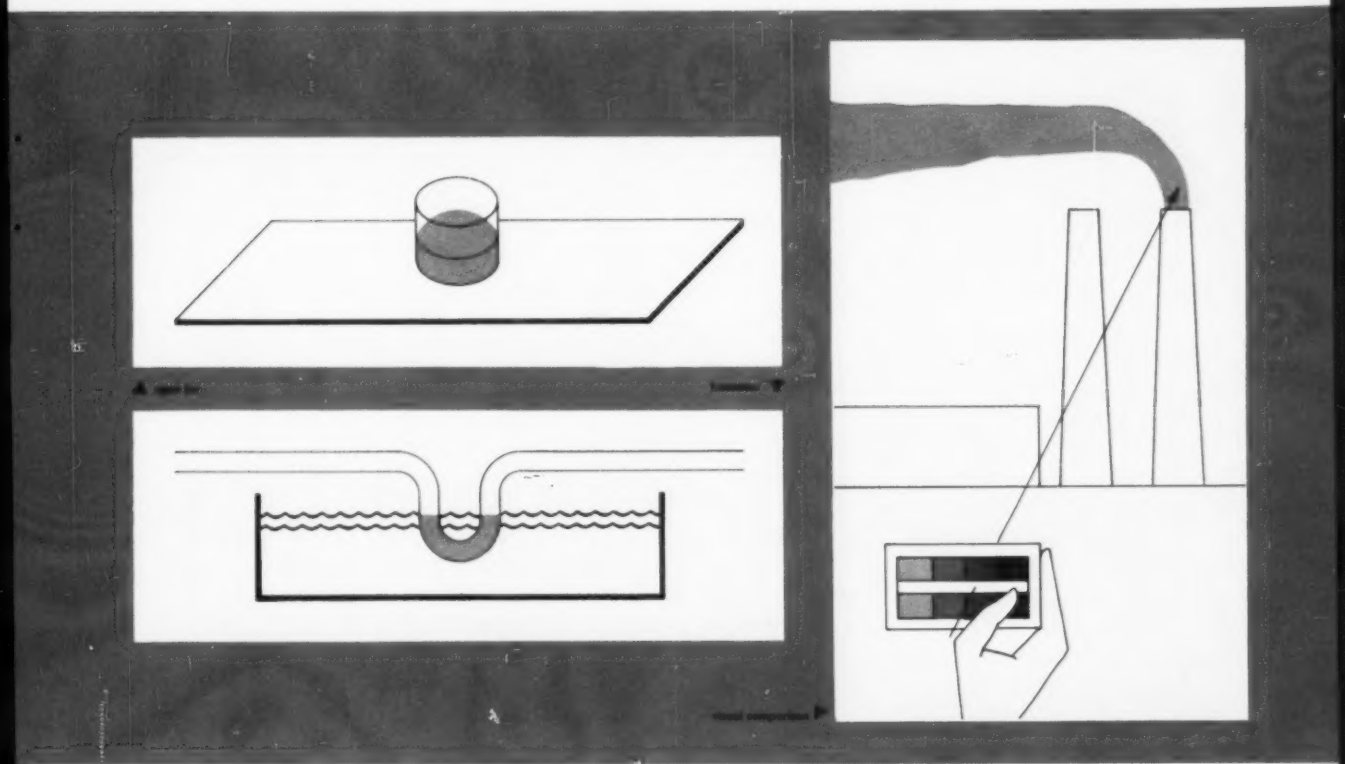
Using its own facilities—backed up by those of the state health department, the U.S. Public Health Service and other research facilities—the control department would employ sampling and inspection techniques, shown typically below. Such continuous monitoring would keep Central City aware of its progress toward air-pollution control. Knowing the complexity of the overall problem, Central City was determined that the air-pollution-control administration keep pace with advancing technology, continue to exercise control on a nonpolitical basis and on an impartial "cause-and-effect" relationship.

In line with the self-enforcement approach, the mayor appointed an air-pollution-code committee composed of representatives of the city's leading industries. He requested that they devise an "emission-limits" code for the area. Committee would be free to select various limits which study showed to be most effective and economically feasible. These limits, recommended to the Control Board, would have been developed by top engineering and scientific talent. It would be unlikely that they would be considered arbitrary or unreasonable by those having to operate under them, and they could cut the air-pollution-control department's operating cost considerably. Industry would be less reluctant to invest in cleaning equipment when it had itself determined the need. It would be encouraged to do an effective cleanup job, knowing the code wouldn't permit discrimination.

Central City took other steps. Present zoning laws prohibited industry's encroachment upon residential areas. These laws would be revamped to prohibit housing developments in designated industrial areas, thus giving industry a defense against future air-pollution problems.

Central City knew that air pollution respects neither political nor geographical boundaries. So the city asked the state legislature to pass enabling legislation permitting Central City's air-pollution-control board to combine activities with other areas for equitable solution of their common problem, if the need arose.

Central City is reasonably certain that its approach to abatement and control, coupled with the policy of keeping all citizens informed, will bring immediate and long-term results in the form of cleaner air.



To combat problems created by man and nature, Los Angeles tried . . .

Southern California's Los Angeles Basin is blessed by nature with climate and topography that permit one to loll on a sun-drenched beach and, but a few hours later, ride a feather of snow down a ski run. Once, the L. A. Basin enjoyed an atmosphere as refreshing as the lakes nestled in its mountains or the blue Pacific lapping its shores.

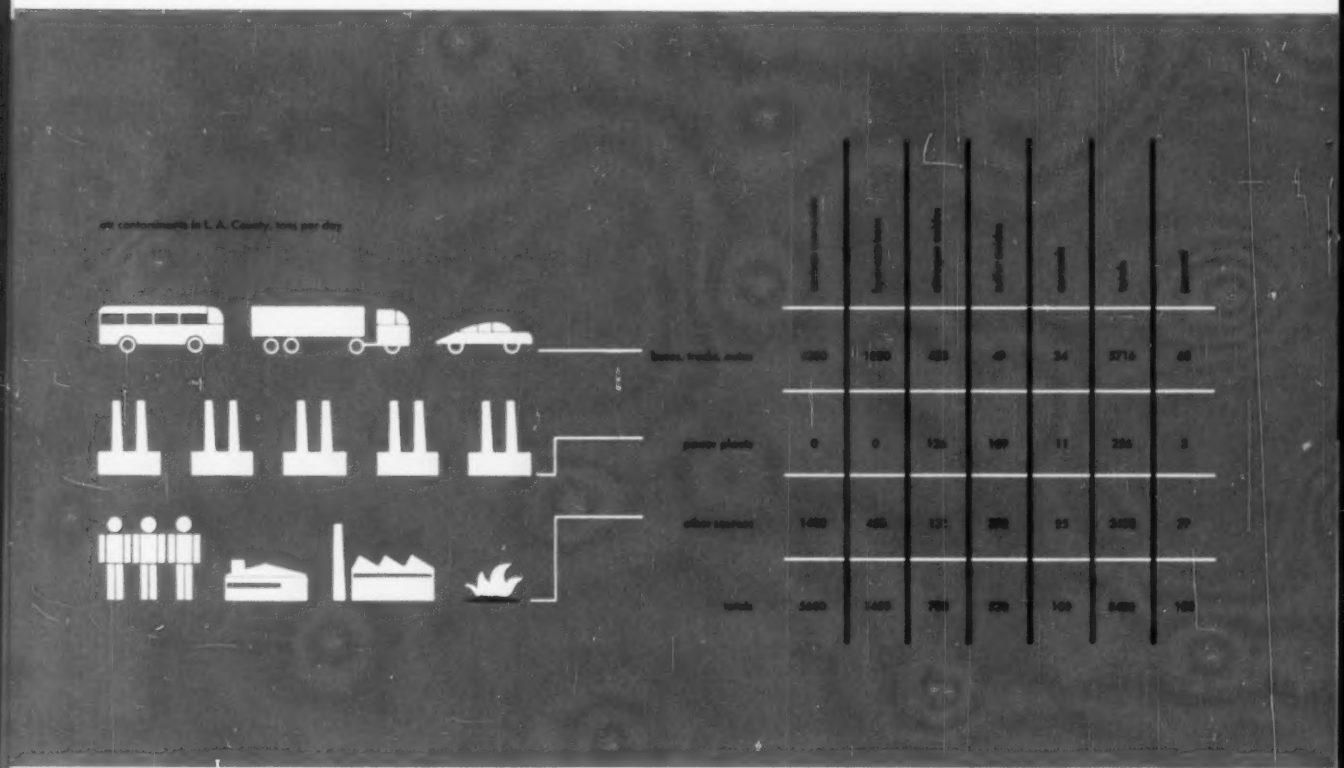
Today, thousands of tons of contaminants entering this atmosphere each day lazily eddy and swirl until the lovely terrain dissolves in a murky haze which climbs ofttimes to the very top of the mountains rimming the basin.

This phenomenon, which has probably spawned more study, more research, more literature, more speculation and caused more dollar expenditure than anything else in the air-pollution field here and abroad is directly traceable to two factors: ventilation and people. Nature, in providing the lovely climate and topography, neglected to supply the area with adequate ventilation. Contaminants put into the atmosphere are trapped there. Thermal inversions cause them to concentrate heavily at or near ground level. Exposed to long hours under a brilliant sun the contaminants cook to form a devil's brew that makes eyes smart, tempers short, and causes untold economic losses. And the principal sufferers, people, are also the principal cause—they put these contaminants into the air in the first place and are now struggling to mend their ways. They now know that cooperation among themselves and with nature is the only road to relief.

Entirely unwittingly, human beings in the L. A. Basin for years let contaminants from their activities rise uncontrolled into the air above them. Little significance did they attach to a matter of historical record: On an October afternoon in 1542 the Spanish explorer Juan Rodriguez Cabrillo dropped anchor in what we know as San Pedro Bay. He noted that although mountain peaks were visible in the distance, their bases couldn't be seen. Smoke from Indian fires rose perpendicularly into the calm air for a few hundred feet, then spread out over the valley. Impressed by this phenomenon, he recorded it in his diary and named the place the "Bay of the Smokes." What the Spaniard saw was the combined effect of a thermal inversion and man-made pollution.

It would be 400 years before these factors were recognized as significant. But their significance was not lost on a September day in 1943, when Los Angeles experienced its first "daylight dimout." One newspaper reported, "thousands of eyes smarted. Many wept, sneezed and coughed. Throughout the downtown area and into the foothills the fumes spread their irritation." An outraged demand for action followed. Citizen committees were appointed. City officials were petitioned. Official investigations were launched. A Smoke and Fumes Commission was appointed, studied the problem, made recommendations. As "smog attacks" recurred, citizens' groups, subcommittees and grand juries buzzed with activity.

L. A. petitioned State and Federal governments for help. City and County Health Officers created air-pollution-abatement groups. A model ordinance was considered



. . . many smog-control tacks before grappling with auto exhaust . . .

by some 46 independent city and county governments—without effective results. They couldn't pull together. Meantime the smog, no respecter of political boundaries, continued unabated. So did the cry of "do something!"

An air-pollution expert from another area was brought in. He studied the problem and made a red-tape-cutting recommendation: Create a county-wide Air Pollution Control District, give it broad powers to enact and enforce adequate regulations. The District was officially created on October 14, 1947; through "enabling" legislation approved by Sacramento, it received practically carte-blanche power to enact its own pollution-control rules and regulations.

The APCD moved fast. *All* outdoor burning was banned. Having no municipal disposal system, Angelinos traditionally burned refuse in backyard single-chamber incinerators. No more. No longer could commercial salvagers fire heaps of automobile bodies. Suitable covers went on oil-refinery storage tanks holding high-volatile products. Gasoline transfer from tank to truck to service station was muffled to prevent vapor escape to atmosphere. Industrial dust-, smoke-, vapor-, mist- or fume-producing processes invested heavily in emission-control equipment. A large steel mill spent millions, installed electrostatic precipitators on its furnaces.

These and a host of other activities resulted from the Air Pollution Control District's edicts. Insistent public demand brought drastic action to control a situation that had snowballed unheeded, as population explosion and tremendous industrial expansion, principally during and since World War II (some 6-million people, almost $2 billion in new capital investment) created atmospheric conditions about which little was known.

The people of L. A. wanted cleaner air and seemed willing to pay for it. But one didn't have to be an economist to deduce who would finally foot the bill.

Power companies' smokestacks immediately felt the onslaught since stacks, large in size, are easily seen by the man in the street. Visible plume, however slight and no matter what its composition, was cause for complaint by jittery citizenry. Considerable emotion was involved and instrumental in passage of laws such as those limiting sulfur content of fuel oil to a virtually impossible level—despite lack of established proof that sulfur was a culprit. Many engineers across the country look askance at this regulation, and another which permits Ringelmann smoke chart use to judge opacity of stack plumes of other than black smoke. L. A. Basin utilities have spent vast amounts of time, talent and money trying to comply with plume-opacity requirements. Experts doubt that success is possible within the realm of economic reality.

Despite the stringent enforcement measures, eye-stinging smog continued to persecute the public, indicating that the real answer still eluded its pursuers.

In recent years the search has been intensified. Careful scientific research—fostered by the APCD, the Western Oil and Gas Assn and the private, nonprofit, independent Air Pollution Foundation—hinted at an important break-

...pointing up need for careful study beforehand

through. They found that a unique and complex chemical reaction occurs in the atmosphere, catalyzed by the famous Southern California sunshine. Actors in this drama are products of all combustion processes and those associated with hydrocarbons handling. As regulations closed in on refineries and all combustion processes, domestic, industrial and utility, without producing significant results, a previously little-considered source took the spotlight: the motor-vehicle exhaust pipe.

In the L.A. Basin's 4000-sq-mi area public transport is relatively nonexistent. The inhabitants, to a man, use the automobile to move about the area. Some 3-million internal-combustion engines puff along streets, byways and freeways pouring almost 6000 tons of pollutants per day (68% of total) into the air over Los Angeles County, while power-plant stacks in the area contribute a mere 256 tons or 3% of total air contaminants. Remaining 29% is attributed to miscellaneous sources.

Research efforts by the automotive and associated industries and sponsored groups focused on combustion improvement, less fuel loss and special catalytic-combustion or afterburner devices. With the passage of Assembly Bill No. 17 on April 5, 1960, California took legislative action.

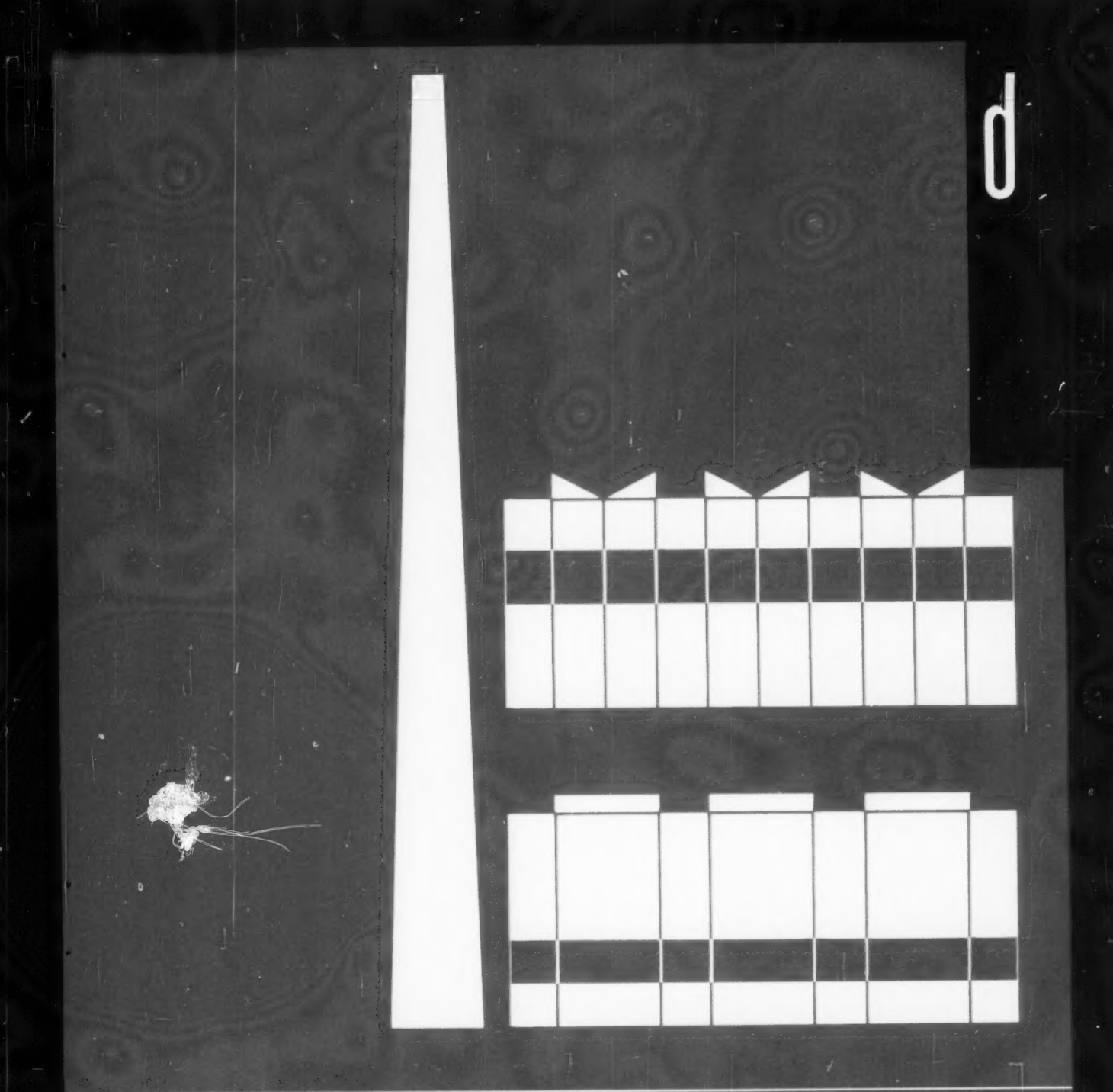
The new law sets up a time-table for installation. Measured from the day a state board certifies that at least two devices are approved, the schedule runs: Within one year, all new vehicles must have control devices. Commercial vehicles must have devices within two years; *all* motor vehicles within three years. According to a report issued by the Los Angeles County Air Pollution Control District, "this new law promises the virtual end of smog in the Los Angeles Basin within five years, *if*: (1) Devices are developed and installed as scheduled and (2) strict control is maintained over pollution from industry and the disposal of rubbish."

Just how soon devices will be approved, how much they will cost the vehicle owner, how they will be maintained, what sort of inspection procedures will be set up, and length of their service life—aside from how effective they will be—is of interest to all concerned with a-p control across the country.

Why, we may ask, did so much time elapse before the automobile came to the fore as an air-pollution source? And we may question other regulations attempting to eliminate smog in Los Angeles. Post mortems are revealing. We all know the wisdom displayed by the Monday-morning quarterback. When the L. A. Air Pollution Control District took over, it was the rookie pitcher fresh from the farm team. It walked onto the mound, found the bases loaded with none out. It knew little about its opponents. So it simply pitched.

In Los Angeles the APCD was up against what is probably the most complex meteorological, topographical and pollutant-source combination in existence. Pressure to "do something" was tremendous from all directions. It went after, obviously, open burning of all types. It moved against smoke emission from stacks and chimneys. Hadn't this solved a major portion of the air-pollution problem for St. Louis and Pittsburgh? It put stringent limits on allowable sulfur content of fuels because sulfur in our lungs *must* be bad for us, and so on. Thus the APCD moved, spurred by public outcry and with little concrete technical help available anywhere in the world, against what seemed the most likely offenders.

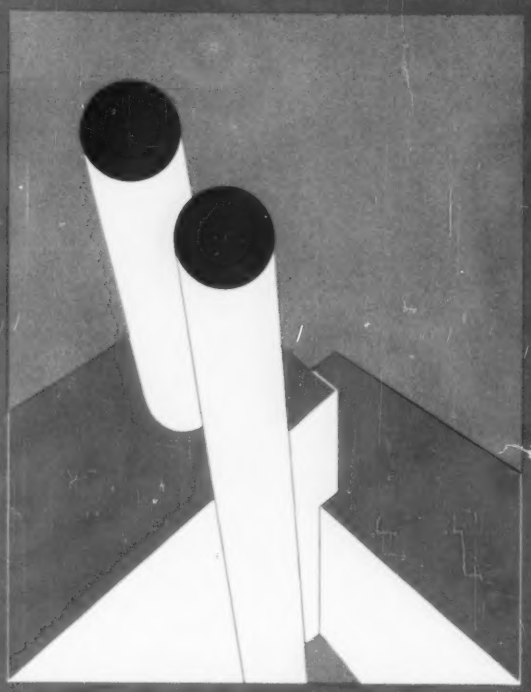
Time alone will show what mistakes have been made. The APCD most certainly can take credit for progress to date. But the errors must be charged to the inhabitants of the Los Angeles Basin. They let the situation get out of hand, then demanded a crash program for relief. Chief lesson to be learned from their situation, then, is that air pollution *must* be recognized and plans for controlling it made when it is the potential state, not after it grows into an actual and serious problem. As in hypothetical Central City, citizens who plan to control air pollution before it controls them are already wise and quite likely wealthier and healthier.



Your plant and pollution: Because any community nuisance is but the sum of many individual nuisances, effective control programs begin at individual pollution sources. For us as engineers, this imposes a continuing responsibility to make sure that our plants abide by the spirit as well as the letter of local clean-air ordinances.

There is more involved here, however, than the mere avoidance of penalties or litigation. Being a good neighbor from the pollution-control viewpoint can be a major factor in sound public relations. And it can be good business in another way, as well: Emission of pollutants—smoke is a prime example—is often an indication of inefficient operation. Or in some cases it can mean the loss of materials worth recovering.

The pages that follow outline how intelligent plant design and location can eliminate pollution problems at the start, and then how problems of existing plants can be mitigated.



Pollution-making potentials of a proposed new plant should be known and evaluated before the site is finally decided and detailed design begun. This means looking at each process and operation to gage what pollutants it might normally produce and to estimate, roughly at least, what might be done to eliminate or reduce that pollution. With some idea of pollution potentials and cost of mitigating them, site selection can be approached more intelligently. And the site chosen will, in turn, influence decisions on investment in pollution control.

What might be called "pollution environment" should be added to the usual considerations—labor supply, transportation, proximity to raw materials, availability of water and power—that are involved in site selection. First, what is the general background level of pollution at the proposed site, and what are the local ordinances controlling pollution? Are there nearby plants whose emissions might damage your product, or neighbor plants that might be sensitive to your emissions? Any risk of damage to vegetation of nearby farms or parks? Would proximity of residential areas call for special public-relations effort even though you comply with local ordinances?

When you design a new plant: analyze its potential pollutants...

A surprising number of today's pollution problems could have been solved at the beginning, with little or no expense compared with the cost of curing or mitigating the conditions now. In other words, it's just good business to make pollution control an integral part of the process of selecting a site and designing a new plant.

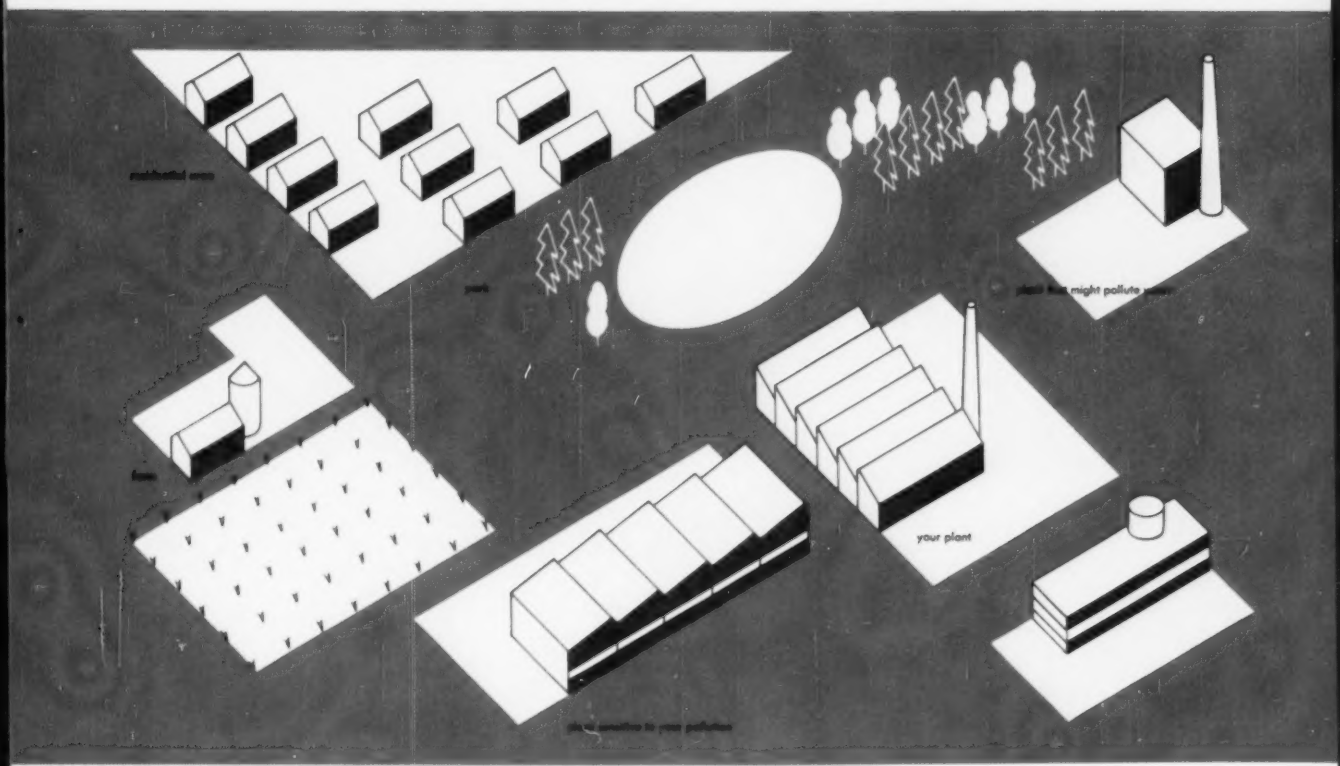
Consideration of pollution aspects must begin early, because it can affect and be affected by plant location and process design. A good way to start: estimate the pollution potentials of the projected operations. In some light-manufacturing or assembly plants pollution possibilities may be nil, or include only emissions from the stack of a boiler plant for space heating. On the other hand, a steel mill presents many potential pollutants: dusts from handling large masses of friable raw materials, dust, smoke, iron oxides and sulfur gases from open hearths, acid and palm-oil fumes from pickling and tin-plating, fumes and zinc oxides from galvanizing, and a variety of others. And for certain processes, say some in the nuclear field, pollution potentials may be an overriding concern in location and design.

In any case, it will pay to examine each process or operation to determine if it normally produces air pollutants, and to establish the nature and approximate amount of pollution. Along with this should go some thought as to what might be done to reduce or eliminate the pollution and a rough idea of what this might cost.

Drawings, above right and on the next page, symbolize some of the many site factors that may influence the pollution-control problem. They also serve to dramatize the fact that air pollution is always an environmental matter. Even if your plant emitted nothing, it would usually operate, and your people would live, in an atmosphere containing pollution from other sources. In the typical situation, of course, your plant *will* have some emissions and how much of a nuisance they create will depend on where they go and who they affect.

Obvious factors in site selection thus include the general pollution level of the environment, specific sources that might be injurious to your operations, and local features that might put more-critical limits on your own plant's emissions.

If the general pollution level is low, for example, even moderate visible emissions from your own plant might single you out, create public-relations problems. In such a situation the effectiveness of your control might need to be much greater than required by the usual ordinances. On the other hand, a high general level of pollution almost inevitably means increasingly strict regulation; your own program would need to make allowance for this.



...consider the pollution environment in which it may be located...

In addition to studying what could be called the "pollution environment," a site-selection survey needs to examine thoroughly the topography and weather conditions of the area. The broad reasons for this can be seen readily. Under favorable conditions, discharged pollutants can be carried away and dispersed so completely that no nuisance is created. Much more frequently, however, topography and local weather can work together to create a variety of problems that may prove serious, particularly if not anticipated. The well-known temperature inversion that may blanket an area with stagnant air is an example.

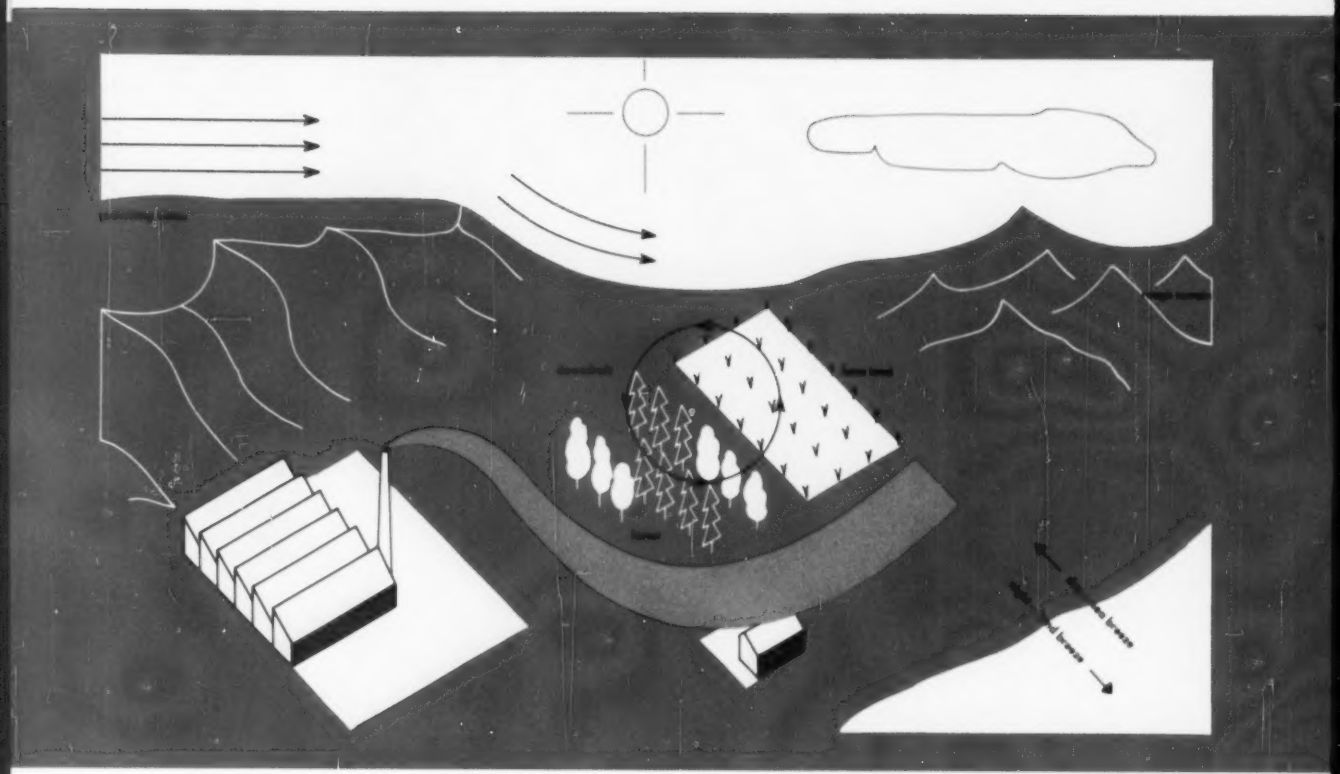
Some of the factors involved are: (1) the nature of the emission—rate, temperature, particle size, concentration, chemical characteristics, toxic or nuisance properties (2) discharge factors such as height of discharge, velocity, relation to surrounding structures and terrain (3) meteorological conditions—wind speeds and directions, temperature and humidity, atmospheric stability, topographic effects.

While it is easy to list the elements of the problem, their appraisal in any given actual situation is usually complex. Three basic approaches are used; in general, each is applicable to a different condition. For analyzing the emission problem of an existing plant, a practical method involves the sampling and measurement of contaminants in the air and on the ground under a variety of weather conditions. By applying atmospheric-diffusion theory and meteorological know-how to such information, pattern of pollution dispersion can be determined. Tests of model plants and terrains in wind tunnels can be a help in solving problems of existing plants and in checking performance of plants designed for specific sites.

When it comes to site selection, it is usually necessary to depend on statistical studies of Weather Bureau data and theoretical analyses based on weather data and the known facts about emissions of the proposed plant. The Weather Bureau Tabulation Unit at Asheville, N. C. will prepare statistical summaries of data at cost, and the Climatological and Hydrologic Services Division of the Bureau at Washington, D. C. can also be of help.

This is, however, a highly specialized area and the plant designer would be well advised to seek expert guidance. Qualified private consultants can be contacted through the American Meteorological Society.

How extensive a study the consultant is asked to make will depend, of course, on the seriousness of the anticipated problems. In many cases it may be enough to have the expert scout the site situation, spot conditions that would obviously create difficulties. But for plants



...study the possible effects of topography and local weather...

where nature or amount of emissions are critical, a fully detailed study is amply justified.

When the site is finally chosen, it may prove desirable to accumulate more-detailed information about it. This might include additional weather data such as wind directions at close intervals of time, measurement of surface humidity and temperature as an index to stagnant-air conditions. Effect of terrain cannot be overestimated: detailed information is needed to spot contours that might act as cold-air dams, etc. Finally, it may be a good idea to make a vegetation survey to set a kind of bench mark against which effects of future discharges can be gaged.

As plant design progresses, each piece of equipment and each process should be reviewed in light of previous estimates of pollution production and characteristics of the site. If site conditions are favorable for waste disposal by atmospheric means, less-complex and -expensive equipment may prove suitable. And, of course, under unfavorable conditions some of the original pollution-abatement ideas may need substantial scaling up.

An important part of plant design will be locating and fixing the height of the stack or stacks. This needs to take account of all the meteorological data collected and of the physical environment. For example, if there are buildings nearby, stack needs to be higher. Here is a situation where wind-tunnel testing finds effective uses.

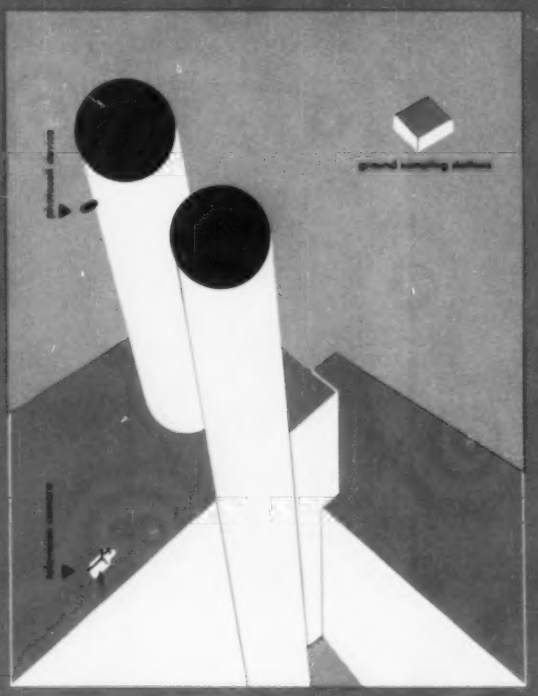
Pollution-conscious plant design must include means for checking pollution-control performance. In many process situations, good operating instrumentation will reveal conditions that raise the level of pollution production. In other cases it will be necessary to add instruments to warn of excessive pollutant production. Example: visible pollutants can be spotted by TV cameras focused on stacks, by photocell devices, etc. Samplers and analyzers handle many nonvisible pollutants such as gases. And ground-station sampling units can be laid out to check actual conditions at selected locations.

During the startup of a new plant, pollution limits may be exceeded either because equipment and processes are not yet properly adjusted or because abatement devices are temporarily bypassed. Every effort should be made to avoid startup pollution—this is the most-sensitive period from a public-relations viewpoint. The impression you make at this time may unfortunately prove almost impossible to eradicate by later good behavior.

When the plant settles down to regular operation, some form of pollution survey needs to be made to see if performance comes up to design anticipations. This may involve only spot checks of dirt fall and air conditions at locations where the meteorological and topographical data

Topography and weather conditions at the proposed plant site need careful analysis, particularly if you cannot avoid some pollution emission. For example, would downdraft on lee side of a bluff bring smoke or dust plume close to ground before it has a chance to disperse? How about effect on dispersion of rough ground downwind from the plant? Are there local circulations caused by differences in solar absorption between, say, farm land and forest? Would the existence of a so-called sea breeze affect day-shift operations of a plant on the coast? All these and many more questions need to be answered to guard against unexpected problems that might arise from the interplay of site topography and local weather conditions.

If your new plant has been designed to reduce pollution emission to a minimum and located so that minimum will not create nuisances, it is only wise to go one step further and provide for monitoring plant exhausts. This might involve photocell devices and TV cameras for visible emissions, sampling equipment to check vents and discharge points for gases and non-visible contaminants. And where justified, it might also involve ground sampling stations spotted in sensitive locations.



...and, finally, provide means for monitoring plant's emissions

indicate possibility of trouble during critical weather conditions. In some cases, more-elaborate sampling may need to be done over a period of time. In all cases checks should be made on the various plant-design factors: actual nature, amount and concentration of pollutants from the various processes; performance of abatement devices.

Preceding discussion of steps involved in making pollution control an integral part of site selection and plant design has, of necessity, been general in nature. This basic procedure applies with equal force to the design of the plant's energy systems, but it will pay to give special attention to the following:

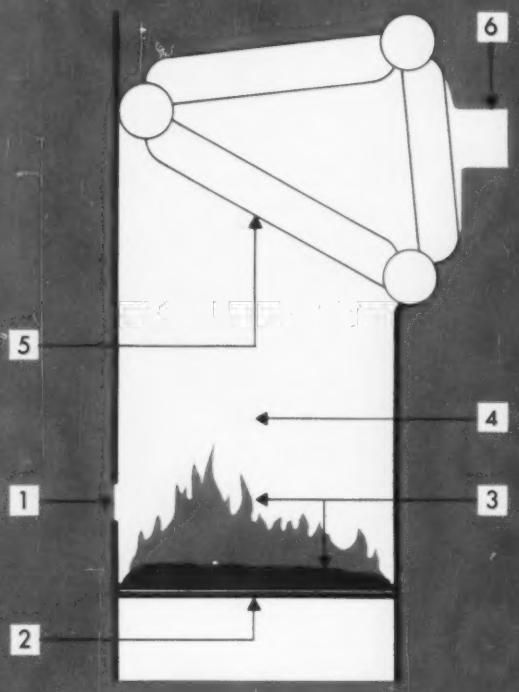
Handling systems for solid fuels often present dust problems. These may be allayed by use of wetting agents and by dust-tight construction of handling-system equipment. In the case of gaseous and liquid fuels, pollution possibilities reside mainly in vents and leaks.

Modern steam-generating equipment should operate smokelessly if properly selected and applied. In specifying equipment and evaluating proposals, provide as much fuel flexibility as economically possible. Be sure loads are adequately stated and allow for the growth that usually occurs: an overloaded unit is apt to be a pollution offender. Perhaps most important of all—in the interests of keeping investment to a desired minimum, don't skimp and cut corners on design elements—adequate furnace volume, for example—that will insure efficient, complete, smokefree combustion. You'll be money ahead in the long run if you shun such false economy.

Formation of nitrous oxide in boiler furnaces has become a pollution problem in areas where photochemical action creates smog. Combustion reactions leading to NO have been described earlier. Current thinking on ways of reducing NO production in furnaces involves 2-stage burning of fuel. Furnaces are designed to introduce 90% of theoretical air needed at burners. Remaining air needed to reach about 115% total air enters combustion chamber above the main burning zone. At this lower temperature combustion is still complete, but NO formation drops off by about 30%. This design should be considered if NO is a potential smog-former in your plant's area.

A different form of 2-stage combustion can be applied to incinerators. Old problem of distilled vapors and unburned refuse can often be solved by following the initial furnace with a second combustion zone. Extra fuel and air is added to complete burning to CO_2, H_2O and ash.

Where pollutant emissions can't be eliminated or reduced by process and equipment design, you'll need to think in terms of collectors and other abatement devices.



1 Good combustion begins with delivery of fuel to the furnace. In fuel-bed firing, this means selection of fuel type and size consist to match firing equipment, and maintenance of proper bed thickness. Size segregation must be avoided. In suspension firing, burner must deliver finely divided particles and develop high scrubbing action between fuel and air.

2 Air distribution through fuel bed or at burner is vitally important. Unbalanced flow through fuel bed causes uneven combustion conditions; it is particularly important to avoid air leakage at side of bed through settings. In suspension firing, all air through burner must be carefully matched to combustion needs and distributed to insure intimate mixing.

3 Solid fuels involve carryover. In fuel-bed firing, partly burned fuel particles and ash may be lifted from the bed by high-velocity air; some flyash may form in the combustion space. In suspension firing, all ash appears in the furnace space and the small particle size and turbulence tend to carry a large share of it into the gas stream to the stack.

In existing plants, good operation and maintenance are musts...

With equipment design and plant environment largely fixed, the pollution-control problem for the management of an existing facility lies in learning how to secure the best results possible within the limitations these impose. And, where "best possible" results aren't good enough to meet local ordinances, how to effect practical modifications that will bring emissions down to satisfactory levels.

Influence of operation and maintenance in this situation can be seen very clearly, for example, in the case of a diesel-engine generator. Here is a unit that should present no pollution problems. But let the engine be overloaded and visible smoke appears in the exhaust. Or let a fouled injection system or worn piston rings develop and again the exhaust shows it.

For energy-system engineers charged with management of existing plants, a major pollution-control concern in many cases is furnace combustion in steam generators, incinerators, etc. As diagramed above, these may emit products of incomplete combustion such as smoke and intermediate hydrocarbons in gaseous form, and products representing the carrythrough of fuel elements such as flyash, unburned fuel particles and sulfur gases.

Chemistry of the furnace combustion process has already been outlined, but while it *is* a chemical reaction, most problems associated with it are mechanical. Fuel must be prepared for burning, it must be brought into active contact with sufficient amounts of oxygen, and the resulting burning has to take place under conditions that insure completion of the process. Each of these steps, as listed in the panel above, depends on mechanical actions and devices and the skill with which they are operated and maintained. Here we have space only for highlights of each firing method and fuel: for greater detail see *Fuels and Firing* (POWER, Dec 1948) and *Clean Air*, a series that began in July 1947 and ended in Jan 1950.

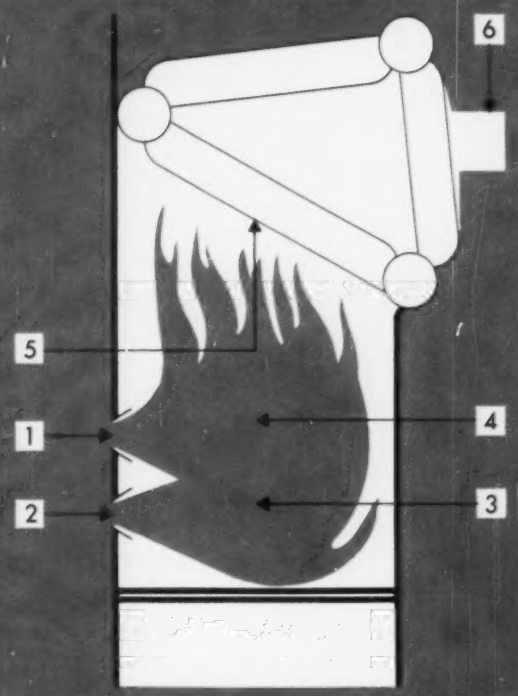
For all practical purposes oil and gas fuels present no entrained-solids problems since there is little or no ash. Sulfur content of some fuel oils will yield objectionable sulfur gases in stack discharge, but this cannot be avoided, only abated, as with scrubbing equipment. To assure complete combustion make sure that burner gets uniformly free-flowing oil, clear of sediment. This means avoiding sediment buildup in storage tanks, keeping strainers in good shape, controlling preheat temperature carefully. Watch for wear of burners and carbon buildup. Many smoke troubles arise from faulty air supply. If installation is manually controlled, make sure air supply is regulated when oil flow is changed. Keep air inlet and fan blades clean; clogging dirt and lint gradually cut air flow.

Smoke is often produced in starting oil-fired furnaces

4 The combustion process begun at the fuel bed or the burner moves to a successful conclusion in the furnace space if air and fuel are continuously and vigorously in contact. Turbulence diminishes the possibility of air-fuel stratification, lengthens the time available for the combustion process and increases relative motion between the air and the fuel.

5 Smoke and other products of incomplete combustion result if chilling effect of boiler tubes and other "cool" surfaces stops the burning process. Basic answer is ample furnace volume, but the limitations of undersized furnaces can be overcome in many cases by increased turbulence provided, for example, by suitably located high-velocity air or steam jets.

6 Stack emission could include gases such as intermediate hydrocarbons, sulfur and nitrogen compounds; suspended particles or "smoke"; entrained solid particles of ash and unburned carbon. Careful fuel selection and attention to fundamental principles of combustion can eliminate some of these entirely and reduce the amount of others, such as flyash.



. . . to hold pollution to minimum possible with available equipment

because of cold surfaces. Always start with a moderate flame, shifting to high flame only when furnace has warmed. If steam for preheating isn't available during startup, arrange to use light oil until the furnace is hot and preheating can be done properly. Avoid overloads!

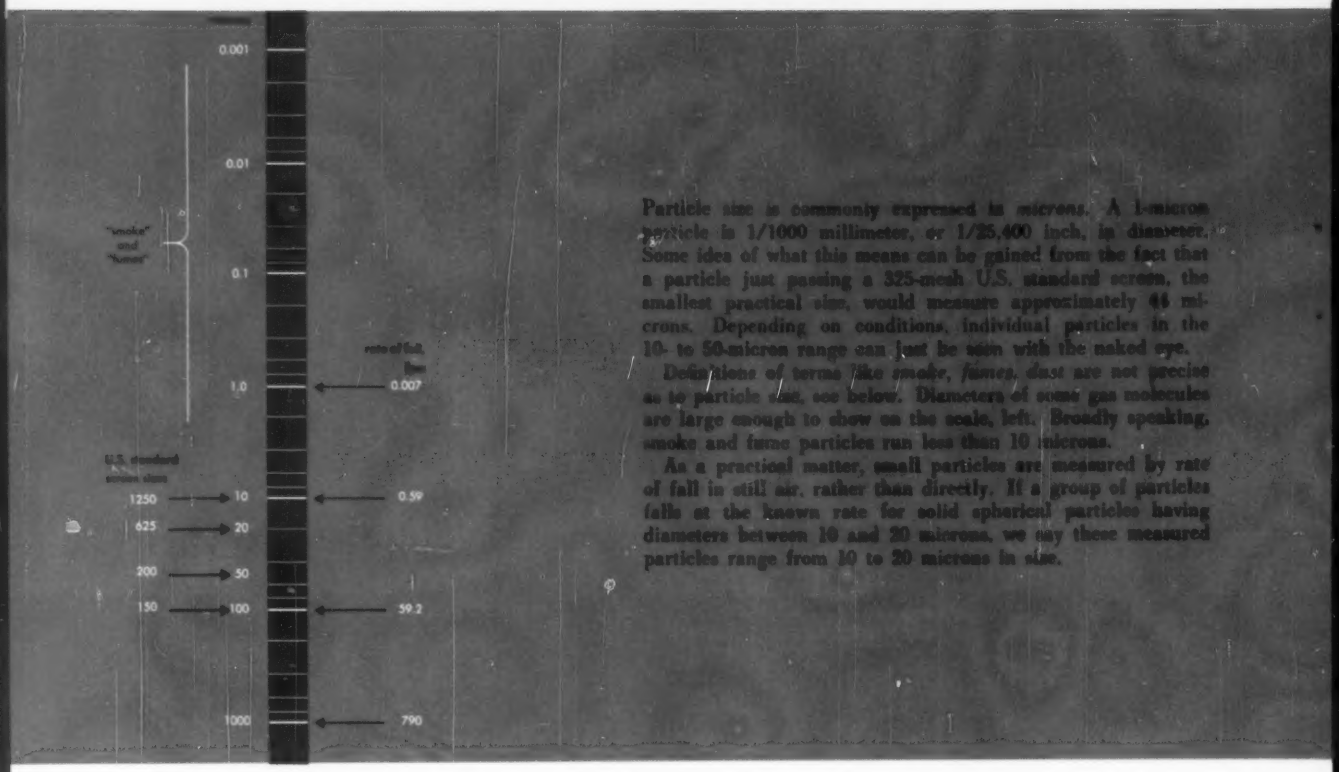
In contrast to gas and oil firing, entrained solids are the usual major problem in pulverized-fuel installations since the coal burns to ash while in suspension. In addition to insuring smokefree operation, complete combustion will reduce the total entrained solids which may include unburned fuel as well as ash particles. In virtually all cases the dust problem of pulverized-fuel units is solved by external collectors, see next section.

Today's widely used stoker, the spreader, burns fines in suspension, larger sizes on a grate. Both flyash and smoke may be problems. Good operation starts with coal having a size consist suitable for the specific unit and avoiding segregation. Control of air flow is of prime importance; it can't be maintained if leaks develop along sides of grate. High burning rates will greatly increase emission.

Chain- and traveling-grate stokers, also of the overfeed type, offer smokefree combustion if proper attention is given to size consist, freedom from segregation, maintaining an even fuel bed, low overfire draft and control of air flow. Only when air velocities through the fuel bed are excessive is there likely to be any solids carryover. The underfeed stoker is inherently free from smoke and entrained-solids problems as long as it is maintained in good mechanical condition and operated at conservative burning rates with suitable caking coals.

Many older boiler installations suffer because of inadequate furnace volume and geometry. But the smoke problem of such units can be materially reduced and even eliminated by the use of high-velocity air or steam jets to promote turbulence and mixing over the fire. The design and application of overfire jets has been intensively studied and extensive data will be found in Technical Report No. VII, "Application of Overfire Jets to Prevent Smoke from Stationary Plants," by R B Engdahl, Battelle Memorial Institute and W S Major, Bituminous Coal Research, Inc.

Application of overfire jets is typical of the practical modifications engineers may use to overcome pollution-producing deficiencies in existing-plant design. Other examples: changes in furnace arches and baffles or other features of the combustion space. Modifications to existing plant might also be interpreted to include a shift from one firing method to another or from one fuel to another. Still another modification, or course, is adding one of the collecting devices described on following pages.



Particle size is commonly expressed in *microns*. A 1-micron particle is 1/1000 millimeter, or 1/25,400 inch, in diameter. Some idea of what this means can be gained from the fact that a particle just passing a 325-mesh U.S. standard screen, the smallest practical size, would measure approximately 44 microns. Depending on conditions, individual particles in the 10- to 50-micron range can just be seen with the naked eye.

Definitions of terms like *smoke, fumes, dust* are not precise as to particle size, see below. Diameters of some gas molecules are large enough to show on the scale, left. Broadly speaking, smoke and fume particles run less than 10 microns.

As a practical matter, small particles are measured by rate of fall in still air, rather than directly. If a group of particles falls at the known rate for solid spherical particles having diameters between 10 and 20 microns, we say these measured particles range from 10 to 20 microns in size.

To cope with dust, smoke and gas emission problems, a variety...

As we have seen, many types of pollution can be eliminated at the source by skillful design of equipment and processes. But there are still areas in which even today's best technology cannot prevent the production of some pollutants. And in many existing plants the limitations of older equipment make some pollution formation inevitable.

In these situations, the problem becomes one of reducing to a practical minimum the amount of pollutants allowed to reach the atmosphere, and of handling the discharge in a way that will mitigate its nuisance characteristics. In both cases it is important to know something about the nature and physical characteristics of common industrial pollutants—gases, vapors, smokes, fumes, mists and a variety of dusts.

Pollutants are classified by physical characteristics and by source. Gases, of course, represent one of the three fundamental states of matter. The basic particle in any gas is the individual molecule; for some gases molecule diameters may range between 0.001 and 0.01 micron. Vapors are the gaseous forms of substances that normally exist as liquids or solids.

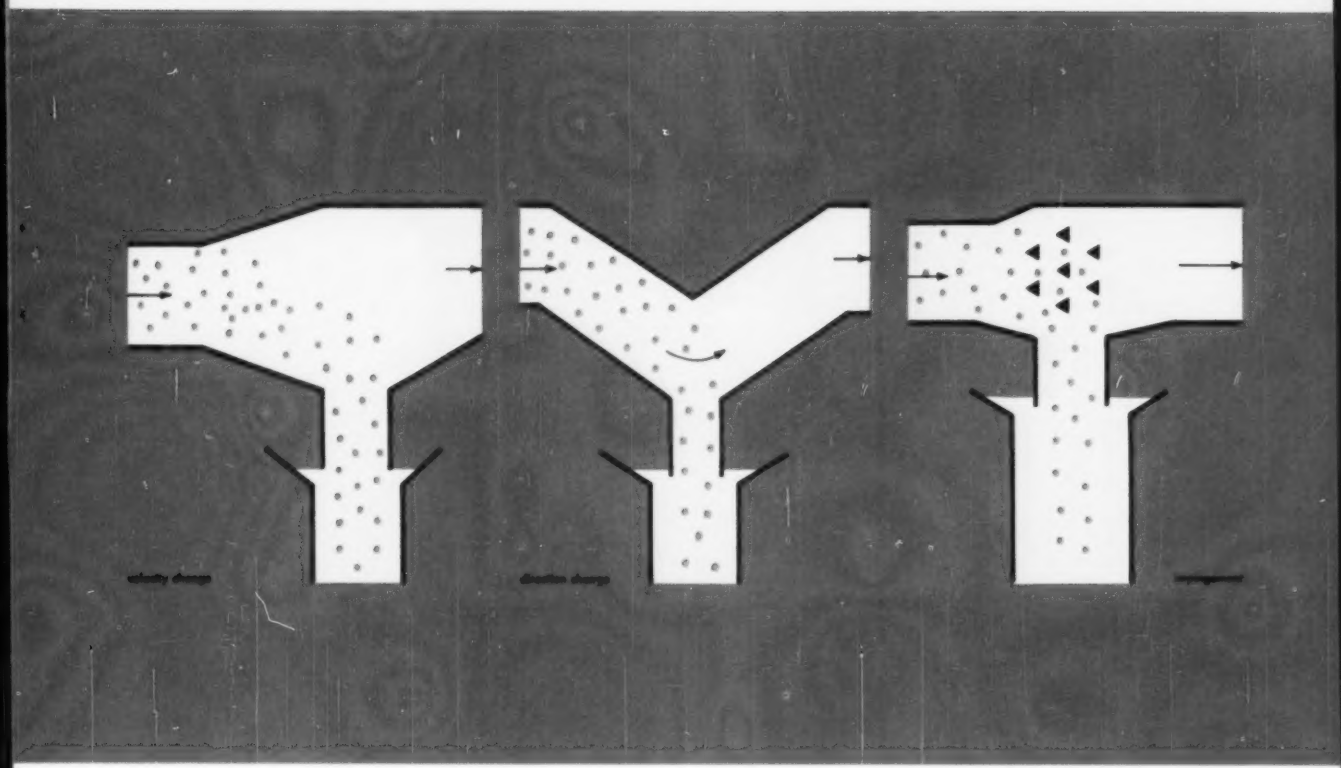
Small particles tend to go into suspension in air or other gases, forming *aerosols*. Generally speaking, when particle size is below 10 microns such suspensions are essentially permanent and the aerosol behaves much like a gas. Except where turbulence is extreme, aerosols having particles larger than 50 microns are unstable and the particles tend to settle out in time.

Smokes and fumes are, in general, stable suspensions of particles visible only in the aggregate, often of submicron size. Properly speaking, smokes are the products of incomplete combustion, consisting mainly of carbon and other combustible materials. Fumes may be defined as very small particles resulting from chemical reactions other than combustion, or from the condensation of vapors produced in combustion, distillation or sublimation. They are commonly metals or metallic oxides.

Dust is an extremely loose term applied to a range of solid particles, usually produced by the physical degradation of larger masses. Dust aerosols are frequently of an unstable character.

Mists are composed of droplets of vapor that has condensed on suitable nuclei. They are stable when vapor pressure of the particle is low or when the droplets are in a gas that is saturated.

If the range of particle sizes found in aerosols is wide, the range of concentrations is even wider. In normal atmospheric air, concentrations of the order of 1 grain per 1000 cu ft are found. Common loadings for industrial gases run 20 grains per cu ft and values up to several



...of methods are available, ranging from basic simple schemes...

hundred grains per cu ft, and more, may be encountered.

In addition to particle size consist and concentration, choice of equipment to remove pollutants also will depend on the volume to be handled as well as the nature of the exhaust stream and its temperature.

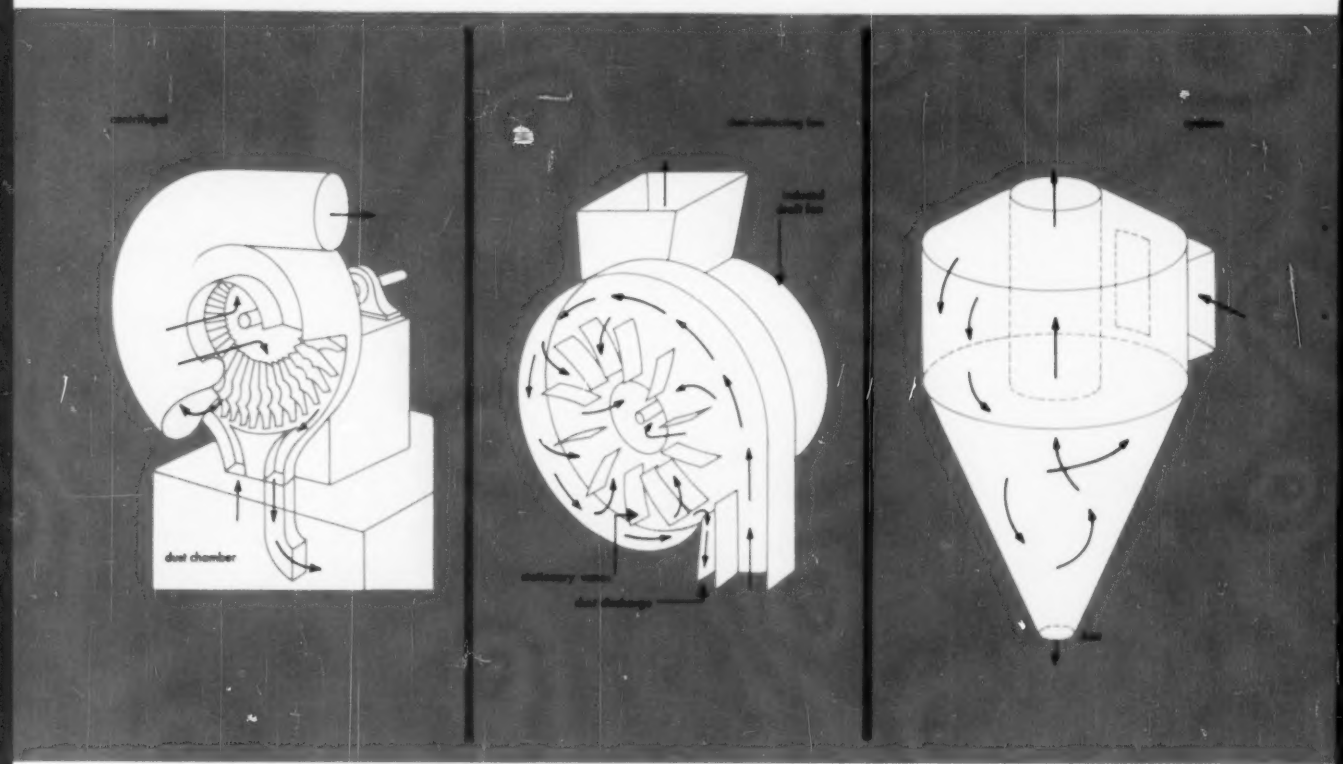
Let's look at the way these various factors are involved in a problem of broad concern—the handling of flue gas from furnace combustion processes. As we have seen earlier, sound equipment design and good operation can virtually eliminate pollutants arising out of combustion conditions—smoke, nitrous oxide, intermediate hydrocarbons. But since most fuels contain some mineral matter that won't burn, and some fuels show perceptible sulfur content, ash particles and sulfur gases may present stack-emission problems.

For all practical purposes, gas fuels contain no ash and oil fuels carry relatively little. But coal rarely contains less than 5% and may carry 20 to 30% or more. Depending on the coal and the firing method, anywhere from 10 to 70% of the ash gets into the furnace gas stream, along with some unburned carbon particles. Some of this flyash or cinder drops out in the boiler passes and breechings, but most of it heads for the stack.

Particle size consist also depends on fuel and firing method. For example, a single-retort underfeed stoker may yield mostly large particles, 75 microns or more, with only a sprinkling of fines. On the other hand, a pulverized-coal furnace may deliver mostly particles under 20 microns, with only a small percentage of larger ones.

In general, the larger the particles, the less stable is their suspension in the gas stream. The sudden change in velocity produced by a wide space in the duct or breeching may be enough to cause heavier particles to settle out. Or, if the gas is forced to flow around a baffle or sharp bend, inertia makes the heavier particles keep going in the old direction and throws them out of the gas stream. Large particles may be "knocked" out of the gas stream by impingement on baffles, illustrated in principle above. In actual cinder traps or cinder catchers, these basic ideas are often combined and elaborated to yield respectable collection efficiencies on large particles.

For finer particles and higher efficiencies, stronger forces need be brought into play. This means collection devices of considerably greater sophistication, involving, in most cases, higher draft losses, more space and greater cost. To an increasing extent such an investment is being necessitated by more-stringent regulations on dust emission. A more or less common limit, for example, is 0.85 lb of dust per 1000 lb of flue gas. An underfeed stoker, burning coal of 8% ash as fired and delivering 15% of



...to centrifugal collectors of several types, various designs of...

that ash to the furnace gas, will show a dust loading close to the 0.85 limit, depending on how much drops out in boiler passes and breechings. Since this example reflects relatively low fuel-ash content and conservative burning rates on a stoker not prone to dust emission, it can be seen that effective dust collection often will be required.

Many types of equipment are available for removing dust from flue gas; diagrams above illustrate operating principles of some of them. In a wide range of collectors depending on mechanical action, centrifugal force is used to separate dust from the gas. This means accelerating the gas stream by a separate induced-draft fan or an integral fan as shown in the dynamic collector, left above.

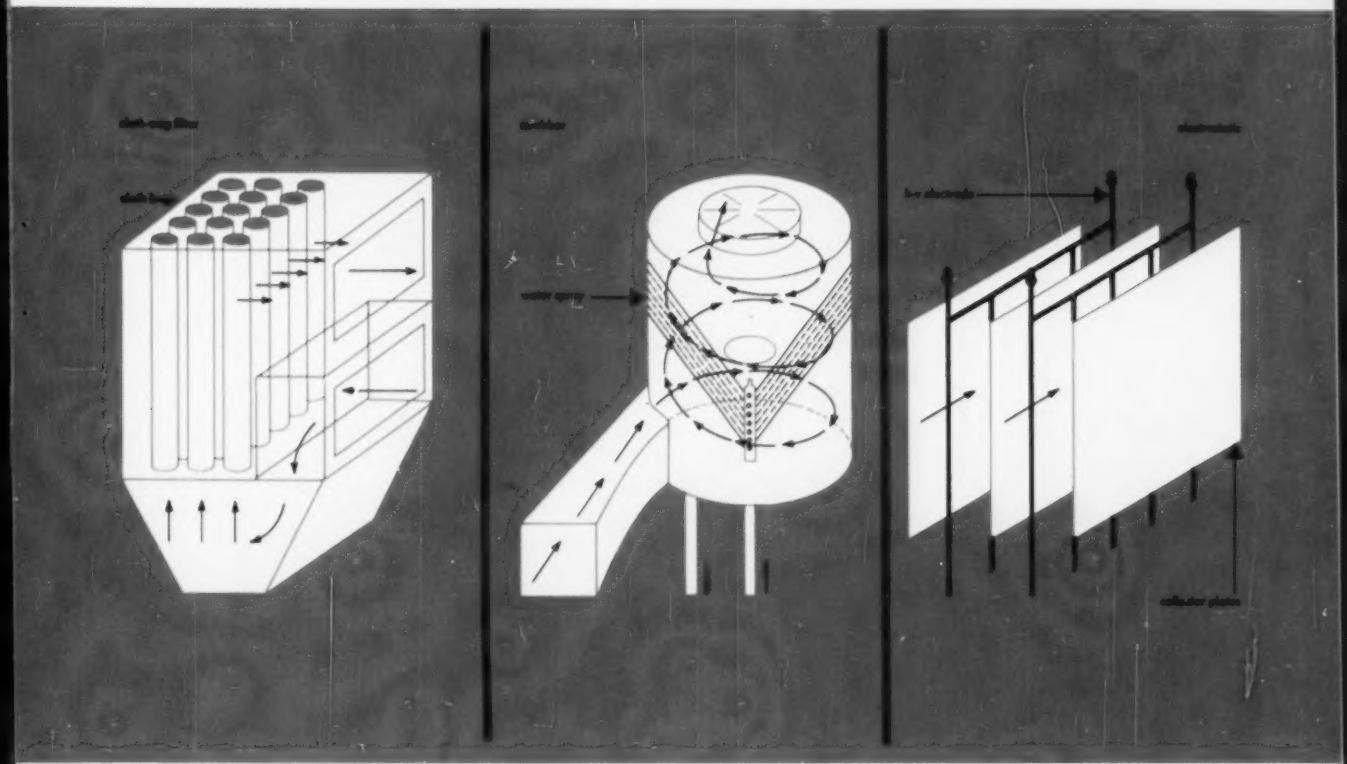
In this design, dust is precipitated by centrifugal and dynamic forces on numerous specially shaped fan blades, is forced along their surfaces to a separate dust circuit within the fan housing and thence to a dust chamber.

Another collector type using centrifugal force consists of a dust concentrator combined with an induced-draft fan. Usual arrangement comprises two such concentrators with a double-inlet fan between them. Outlet sides of the concentrators form the side sheets of the fan. Dust-laden gas enters the primary volute at the outside of the scroll. Decreasing volute radius increases the centrifugal force carrying dust to the outside of the volute. Near the minimum radius a tangential slot removes a small volume of highly concentrated dust-laden gas. A secondary collector may operate on this. Clean gas at center goes through guide vanes to fan inlet.

Most familiar of all collectors using centrifugal force is the cyclone, above. Incoming gas is guided into a cylinder in such a way that a strong whirling action is set up. This generates centrifugal force that tends to throw suspended particles to the outside. Clean gas in the center zone is drawn into a vortex-created updraft and leaves through a center outlet. Concentrated dust-laden gas is withdrawn at the bottom.

In the simple form illustrated, the cyclone is a relatively low-efficiency device with low draft loss. Intensive research on the cyclone principle has led to design improvements that increase the centrifugal force and reduce dust reentrainment. A number of today's designs employ multiple tubes of relatively small diameter.

Gas may be cleaned of dry dusts by passing it at low velocity through finely woven fabric, usually arranged in tubular "bags" or "stockings". While initial removal depends mainly on screening action of the fabric, build-up of removed material on dirty-gas side contributes substantially, giving a high degree of effectiveness even on submicron particles. Draft loss increases as material



...filters and scrubbers, and devices using electrostatic charges

builds up on dirty-gas side and periodically the filter bag must be rapped, vibrated or reverse-blown to drop the adhering dust into the hopper. Units are usually sectionalized so gas flow can be maintained while one or more sections are being cleaned. New silicone-treated glass-fiber fabrics can handle gas temperatures to 550 F.

Wet collectors or scrubbers of various kinds can remove fumes, mists and soluble gases as well as fine dust particles. They are widely used for cleaning discharges from kilns, roasters, dryers and other process equipment. Use on flue gas from boiler furnaces has, in the main, been confined to cases where removal of sulfur gases was important. Wet collectors include spray types such as the scrubber illustrated above, atomizing and venturi designs, dynamic and centrifugal types, packed towers.

Widely used where high efficiencies on extremely fine particles are required, the high-voltage electrostatic precipitator passes dust-laden gas over electrodes between collector plates. Electrodes impart a negative charge to the dust particles, causing them to move to the collector plates and adhere. Removal of collected material involves rapping or vibrating the elements continuously or at intervals. Pressure drop of these collectors is low, and high collection efficiency is nearly uniform over a wide range of particle sizes from submicron up. But space they require is relatively large; cost is apt to run high.

In any given situation, decision as to which collector to use will depend on evaluation of needed efficiency on the particle sizes involved, draft loss and space requirements, cost. In some cases two types are installed in series; the usual combination is an electrostatic preceded by a mechanical type. Prior removal of coarser particles permits more-effective electrostatic operation.

Discussion here of collectors suitable for the relatively large volumes and high temperatures met in flue-gas work should not obscure the fact that industrial plants will have other emissions. Some of the collectors described here will meet some of these needs; for others the answer may be one of the several types of filters discussed in POWER's special report, *Air Conditioning for Industry* (March 1960, pp 53-68).

Odors emanating from industrial processes present another abatement problem. Measuring and identifying the nature of odoriferous materials is a highly specialized job, as is the task of recommending abatement measures. As with other pollutants, odors may be reduced or eliminated at the source by process changes or may be removed, for example, by adsorption in activated carbon. Odors are also neutralized or masked by mixing a pleasant odor with the unpleasant one. This is work for experts.

Looking back over the many facets of the air-pollution problem as explored in this report, it becomes abundantly clear that *people* are the key. People produce pollution; people complain about it; people support or resist efforts to do something about it. People, or more specifically, people's attitudes, make the difference between the success or failure of pollution-control programs.

In a democracy, the better informed people are, the better will be their decisions. Air pollution is no exception – as a matter of fact, it forms a prime example of the need for an informed public. This is not only true for community approaches to the problem; it applies with equal force to the control programs of individual plants and industries.

For the community, public education needs to begin early, usually before there is any visible pollution problem. This is the time when an ordered, reasoned approach can be made, before pressures of an "emergency" atmosphere force hasty, emotional attacks. This is the time when engineers and other knowledgeable members of the community can display vision and leadership: vision to anticipate the problems the future will bring, leadership to convince the people that action will be needed.

At every stage of examining the community's pollution situation and devising a sound control program, the public must be given the full facts, in a manner that all can understand and appreciate. Only in such an informed climate can the problems be tackled and support won for the procedures evolved to solve them.

Such public information must be an integral part of any plant pollution-control program as well. For a new plant particularly, advance information should be given to let people know that pollution aspects are receiving careful attention. People should be told what specific steps are being taken to eliminate or reduce pollution, and how much the company is investing to make their plant a good neighbor.

It is in this area of public education that we believe this special report has its greatest usefulness. We hope it will be put to work both by communities and by individual plants.

Development of high-frequency fluorescent lighting raises a real need in industrial and commercial buildings to . . .

Design distribution for high-frequency lighting systems

By J N ROBERTSON, Dept of Water and Power
Los Angeles, Calif.

Recent development of high-frequency fluorescent lighting creates the need to distribute these high frequencies over wide areas of buildings and industrial plants. (See POWER, March 1957, pp 86-89 and April 1960, pp 98-100.) Previous uses of frequencies above 60 cps in buildings and plants were usually limited to special applications, restricted to small areas. So experience in handling them has been quite limited. This article will review some current information on sources, basic circuitry, high-frequency practices applicable to distribution and branch circuitry for high-frequency lighting.

Peculiarities of high-frequency circuitry are intimately related to the nature of the source. Most sources commercially available to supply lighting systems are either magnetic multipliers or rotary frequency changers. Electronic frequency changers, particularly transistorized devices, are under development but not yet available for this purpose.

Static frequency multipliers convert 3-phase 60-cycle power to 360-cycle single-phase by means of static magnetic-saturating devices. An interesting feature of static multipliers: they may be designed to produce a triangular voltage wave form. This is ideal for lighting because a square-wave lamp current results when capacitor ballasts are used.

Rotating frequency changers (m-g sets) are currently available in two output frequencies for lighting service, 420 and 840 cycles. The 420-cycle sets have 3-phase 600-volt sine-wave output. Output windings actually are three isolated single-phase windings electrically displaced 120 degrees, each midtapped to ground. These sets are not designed for parallel operation; load between windings should be balanced as closely as possible. They are intended for use with lead-lag lamp ballasts. Available sizes are 25, 50 and 100 kva. Nominal full-load efficiencies are 85 to 90%.

The 840-cycle m-g sets are available in two types, single-phase square-wave and 3-phase sine-wave output. They're designed to supply lighting systems with slimline lamps and capacitor ballasts.

Individual phase voltages of 3-phase sets are either 400 or 600 volts, depending on lamp lengths supplied. Since the phase windings are electrically independent of each other they can be wound for different simultaneous voltages. One phase may deliver 600 volts for 8-ft-lamp circuits while the other phases of the same machine may be wound to supply 400 volts for circuits with 4-ft lamps. These machines are available in several sizes up to 225 kva.

Single-phase 840-cycle m-g sets have single windings center tapped to ground, with square-wave 400- or 600-volt output. These sets are available in ratings from 5 to 175 kva.

Parallel operation is not satisfactory for most machines currently manufactured to supply high-frequency energy to lighting systems—unless you add elaborate control systems. In most cases each phase of each machine becomes a separate distribution system within itself. When you want flexibility you'll usually connect each unit to a specific group of lighting circuits and then provide cross switching so one machine at a time may be taken out of service.

Center tap to ground on each winding is another peculiarity almost universal in high-frequency supply equipment. Center tap limits circuit voltage to ground to meet requirements of the National Electrical Code. Even with voltages high enough to fire lamps without using autotransformer ballasts (600 volts for 72- and 96-in. lamps, 400 volts for 48-in. lamps and under), voltage to ground is still not over 300 volts.

Distribution circuitry falls into three basic classes, depending on your choice of equipment:

Base your solution on available equipment

(1) Single-phase 840-cycle 400- or 600-volt power is supplied from m-g set; branch circuits are switched in the conventional manner, diagram at top of next page.

(2) 3-phase (isolated phases) 400- or 600-volt 420- or 840-cycle system is supplied from m-g set; each generator winding is center tapped to ground and each phase operates as a single-phase system, right.

(3) 3-phase 4-wire 277/480-volt (or 265/460-volt) systems operating at 400 cycles are sometimes used in industrial plants. Here the frequency serves a power application and only incidentally supplies the lighting system. These systems use 2-wire phase-to-phase 480- (460-) volt lighting circuits and appropriate lamps.

Details and techniques can bring up some important problems when you're considering layout of high-frequency systems within buildings. Solutions we discuss are based on available equipment, limited to frequencies under 1000 cps. Solutions are primarily for lighting circuits but most are valid for other applications.

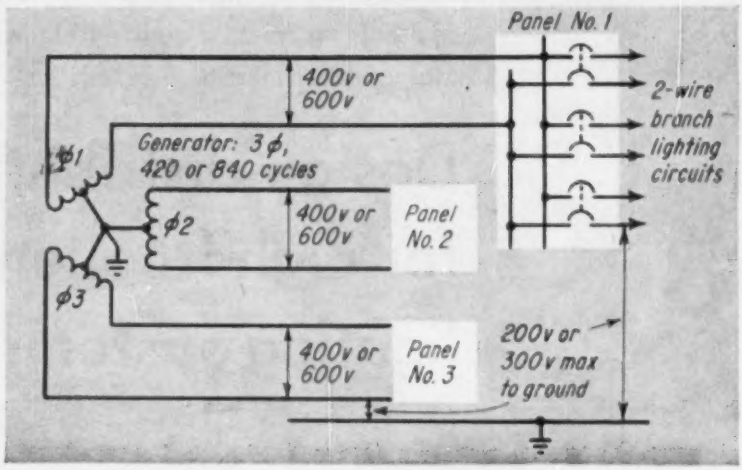
Wire and cable may have to be derated at higher frequencies. High frequency increases reactance of the circuit and hence effective resistance. It can also increase the effect of magnetic materials on reactance heating of wire and cable.

On branch circuits carrying up to 20-amp load with good power factor this effect can usually be ignored. Derating between 60 and 1000 cycles will run from 1 to 6%. Reactance heating of small conductors is also negligible.

Voltage drop for single-phase circuits can be found using this simple equation:

$$\% \text{ drop} = \frac{I(R \cos \varnothing + X \sin \varnothing)100}{\text{voltage}}$$

where I = circuit current
R = circuit resistance
X = circuit reactance
$\varnothing$ = phase angle of circuit current with respect to supply voltage.



3-PHASE SYSTEM, 420 or 840 cycles, 400 or 600 volts, has each winding center tapped to ground. Each phase circuit operates as if it were an isolated single-phase system

Ac resistance (impedance) of both lines of a 2-wire circuit at 30-C ambient on 420 cycles is shown in table, opposite page. Resistances for 840 cycles increase slightly—see accompanying graph for one pair of AWG-10 stranded copper wires.

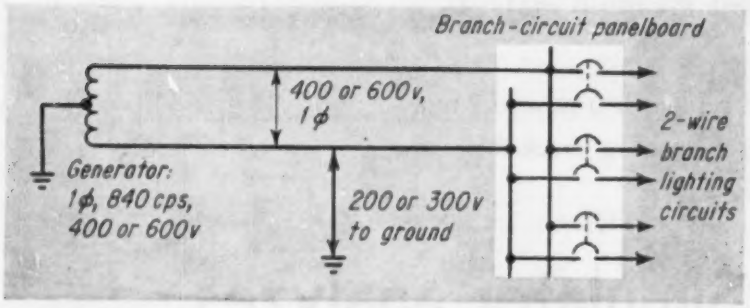
Voltage drops for small branch circuits are not appreciably greater than for 60 cycles if circuit lengths are kept under 300 ft. Sometimes, when lamp circuits have capacitor ballasts, voltage may actually rise.

Special precautions should be taken with heavier circuits. As current and wire sizes become larger, the distribution system should get more consideration. Apply these rules for feeders, subfeeders and branch circuits carrying more than 20 amp: (1) use stranded conductors (2) use nonmagnetic conduit or raceway (3) use close conductor spacing (4) equalize lead length on circuits fed from the same power supply.

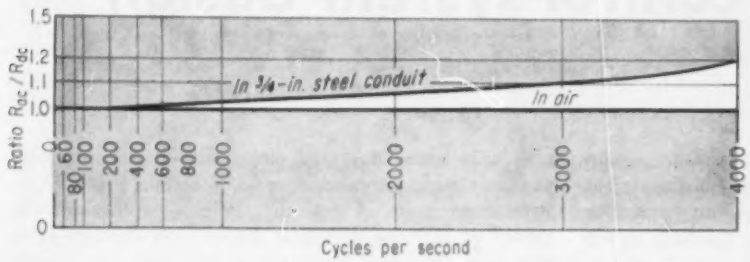
While conventional steel conduit and outlet boxes are satisfactory on small branch circuits, nonmagnetic enclosures are recommended for circuits carrying more than 20 amp.

Switching and protective devices such as standard thermal- and magnetic-trip circuit breakers can be used. Most-common device is the 2-pole molded-case circuit breaker. Breakers should be rated 600 volts, limiting the type to F frame or larger. Circuit breaker must also be derated, says one manufacturer, as indicated in table on next page. This derating adds to the standard factors for duty cycle, ambient temperature and enclosure. The 420-cycle values in table may be used for 360 and 840 cycles —actual values are nearly the same.

Local switching of lights in rooms or small areas is possible, except in systems using capacitor ballasts fed from magnetic frequency multipliers. In systems using capacitor ballasts and power-factor-correction coils, take care that correction coils are switched with their respective lamps and ballasts. Single-pole switches can't be used locally; all switches must be 2-pole and approved for 600-volt operation. You can get 600-v 2-pole toggle switches to fit


Branch-circuit panelboard
400 or 600v, 1φ
2-wire branch lighting circuits
Generator: 1φ, 840 cps, 400 or 600v
200 or 300v to ground

SINGLE-PHASE 840-cycle system is supplied from a motor-generator set. Center-tapped windings provide voltage to ground measuring one-half the system line-to-line voltage



RATIO of ac resistance (impedance) to dc resistance varies with frequency when circuit is wired in steel conduit. Curves are based on one pair of AWG-10 copper wire

Impedance of 2-wire circuit

Wire size, AWG	Impedance, ohms per 100 ft
14	*0.320
12	*0.201
10	*0.1265
8	0.0780
6	0.0502
4	0.0327
2	0.0214

*Two copper wires in steel conduit

Circuit-breaker derating

60-cycle trip rating, amp	420-cycle capacity, amp
15	14
20	18
30	26
40	34
50	42
70	58
100	81

a standard 2½-in.-deep outlet box.

Incandescent lamps can't be used satisfactorily on higher frequencies, as you might like to for exit and emergency lights. Lamps fail after a very short time. So neon lamps are usual for exit and emergency lights.

Wiring carrying high frequency should not be placed in the same enclosures with wires carrying 60-cycle power. Most codes would prohibit this on the ground that they're different electrical systems. And it isn't advisable even where permitted. The higher frequencies probably wouldn't affect most 60-cycle circuits or equipment, but presence of 60 cycles would definitely distort the wave shape of higher frequencies, affecting operation of equipment depending on wave shape purity for good performance.

Wave shape does affect fluorescent lighting. Light output of fluorescent lamps is increased by increasing the frequency, by increasing lamp current and by operating on a square wave form of current.

Power factor can be corrected on h-f systems, and correction is just as important as with 60 cycles. On lighting systems using lead-lag ballasts, power factor will be near unity. On those using capacitor ballasts power factor will be low, leading unless corrected. Power-factor-correction coils are available for this purpose. These coils are connected in parallel with the circuit load being corrected.

Shielding specially designed to avoid interference with communication equipment isn't generally necessary — frequencies we're discussing don't normally interfere with telephone, teletype, radio and intercom circuits. Short flexible cords such as fixture connectors don't have to be metal sheathed. Also, the Federal Communications Commission is not generally interested in frequencies under 1000 cps.

Distribution throughout a large industrial plant or multistory office building from a single vault or equipment room doesn't appear feasible for lighting. Experiences to date indicate that panelboard feeders and subfeeders should be short as possible; branch circuits should be limited to 300-ft maximum. This suggests that supply equipment should be located at the center of large load areas. In tall, multistory buildings frequency changers located at perhaps every third or fourth floor may be the most economical compromise. Incidentally, 3-wire circuits with common neutrals won't work with present equipment. Today's techniques are based on 2-wire circuits.

Locations for frequency changers should be selected with special precautions in mind. Some of this equipment is quite noisy and should be put where noise can be effectively isolated or insulated from adjacent areas. Since power losses range from about 10 to 25%, provisions also must be made for heat dissipation.

Design of high-frequency lighting systems within buildings offers no major obstacles. Aside from the few peculiarities and limitations we've discussed, a conservative design using good-quality materials and equipment and based on familiar 60-cycle technology should be quite satisfactory in nearly all cases.

Dynamic analysis of controlled systems is a powerful new design tool. Ohio Edison used this tool to check their new tie-in control: here's how a . . .

Simulator analyzes control-system design

As interconnected groups come into existence, many technical and operational problems present themselves. To combat some of these problems, definite operating rules and contractual agreements for handling power interchanges were worked out. Success of these procedures depends on each system in the interconnected group having adequate control of its generating equipment so it can recognize minute-to-minute customer-load changes and start corresponding changes in generation immediately.

In recent years it has become apparent that a time lag exists in boiler-control systems which, if minimized, would give better system response to load changes. One possible way of reducing the lag: send regulating intelligence to the boiler-control system simultaneously with load-control impulses to the turbine governor. Thus, when the turbine responds to a change in throttle position the boiler-control system anticipates corresponding change in steam flow and proper amount of steam is produced with less delay.

Tie-in control was to be installed on unit No. 1 at Niles Station of Ohio Edison Company. Several plants include this tie-in system in their basic controls. In this case, thorough testing of tie-in control was accomplished without extensive field programs. System simulation occurred after dynamic analysis shown at right, above. By this time field testing had already begun but the analog computer used for simulation still handled most of the test schedule. It proved much more convenient to make runs on the computer than in the field. Runs could be arranged arbitrarily to give a more complete comparison of the various arrangements. As a result, field data served as corroboration of computer results.

Simulator results, below right, checked performance of 2- and 3-function master pressure controllers with and without tie-in equipment. When tie-in is not in service, master controller must determine proper coal feed on the basis of steam-pressure variations. So a sustained pressure deviation must exist during load change in order to reset coal feed to the new level. Tie-in equipment makes it possible to bypass the master, insert a signal resulting directly in proper coal feed. This is possible only when input and output are known accurately and only with a simulated cycle or certain specially instrumented units. Practically, tie-in acts through the master so pressure deviation during load changes averages zero. Pressure deviations in field data are greater because of irregular throttle-valve motion.

Simulator results verified by field data supported these conclusions: the 3-function master pressure controller incorporating proportional, reset and rate actions provides excellent regulating characteristics above about 70% rating. Performance at lower loads is impaired by reduction in steam-pressure drop from drum to throttle. Tie-in equipment can compensate for this effect at lower loads and improve regulating capability in this load range. But full-load performance is not appreciably affected by tie-in control.

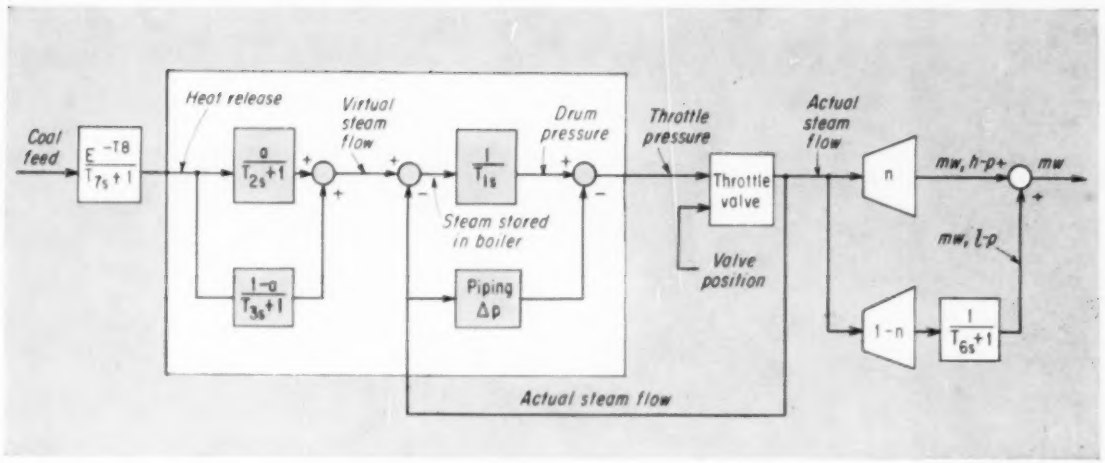
The 2-function master controller with proportional and reset actions imposes some limitation on regulating capability even at full load if the controller operates by itself. When controller is supplemented by tie-in equipment, performance under regulating conditions can be acceptable down to about 50% load.

In both cases improved regulating characteristics are obtained with tie-in equipment without cutting combustion efficiency since fuel and air to cyclones is controlled simultaneously.

One word of caution—application of these conclusions to other boiler-turbine units calls for careful analysis. Settings used on the 3-function master for these tests, both on the computer and in the field, were somewhat tighter than settings which provide the same degree of stability on many other boilers. If another type or size of boiler imposes any limitation requiring looser settings of the master controller, this will generally limit the regulating characteristics that could be obtained without tie-in. So these installations would actually realize greater improvement in regulation than Niles Station.

Information for this article was supplied by a report of R H Travers and D B Zelenka, Ohio Edison Company, H A List and C Nichols, Leeds and Northrup Company.

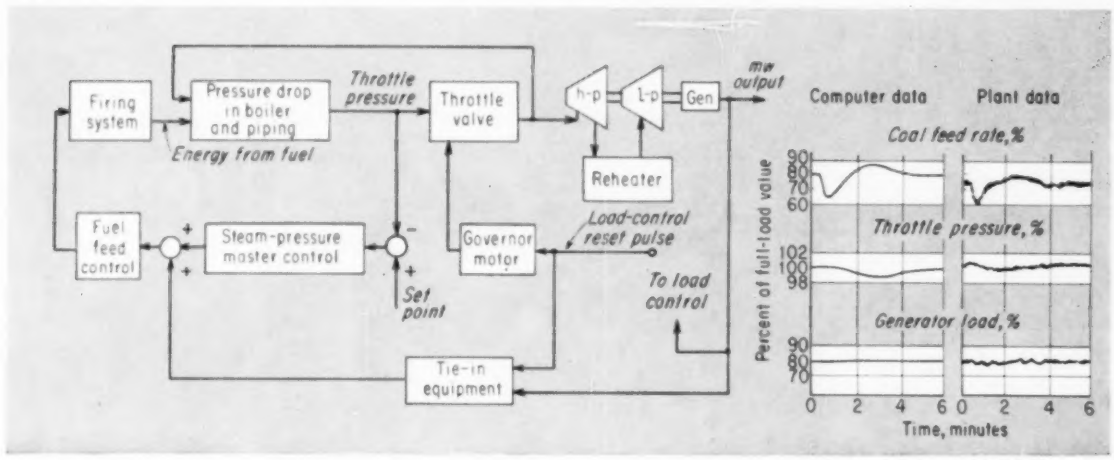
System diagram simulates dynamic response



Operational block diagram, above, of the firing system, boiler, throttle valve, turbine and reheater was first step to simulated unit operation by computer. Time functions of system components were analyzed to determine control response. Starting in upper left-hand corner, time delays between change in coal feed and heat release in the furnace appear as E^{-Ts}, fuel feeder dead time and $T_{1s} + 1$, exponential time lag of heat release. Heat divides between $\frac{a}{T_{2s}+1}$, the portion which appears in the short time T_2 as added steam, and $\frac{1-a}{T_{3s}+1}$, the heat delayed by T_3 because it is added to circulating water. Difference between actual and virtual steam flow is applied to block representing boiler storage, T_1. Throttle pressure is the difference between drum pressure and R, pipe-pressure-drop-resistance term. Magnitudes of time constants and ratios were adjusted to make mw output and throttle pressure agree with actual unit response.

Diagram is based on assumption that h-p turbine converts portion n of steam flow directly to output. Contribution of the l-p turbine, $1 - n$, is delayed by T_6 because of volume of reheater and associated piping.

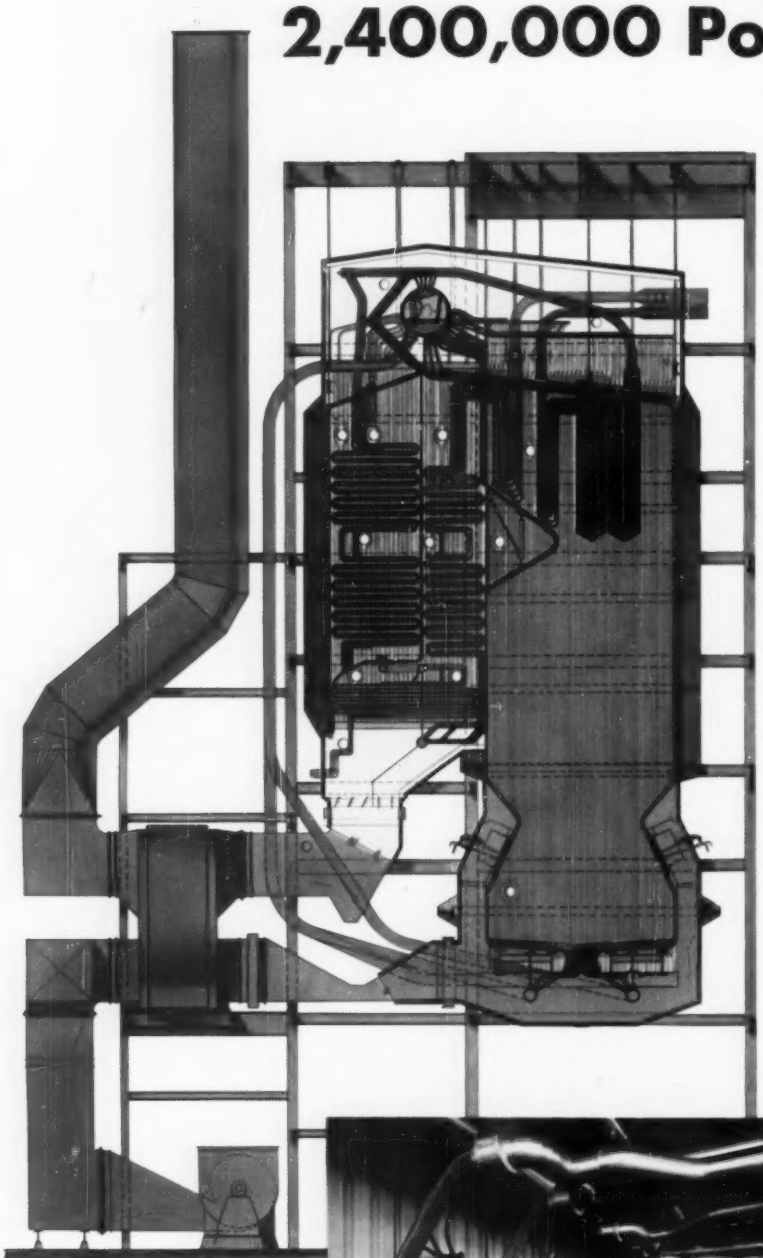
Final operation checks simulator results



Final control system uses tie-in between system load control and boiler control. Agreement between analog-simulator results and actual field data was excellent.

For field tests and simulator studies, 2- and 3-element master controllers were used. The 2-function master responds to steam-pressure variations by moving coal feed an amount proportional to pressure deviation, then resets coal feed until deviation is wiped out. The 3-element master also moves coal feed in response to the rate of change of steam pressure. Field and simulator charts indicate degree of agreement between results, point up value of simulator use in checking control dynamics.

Two RILEY TURBO FURNACE 2,400,000 Pounds of Steam



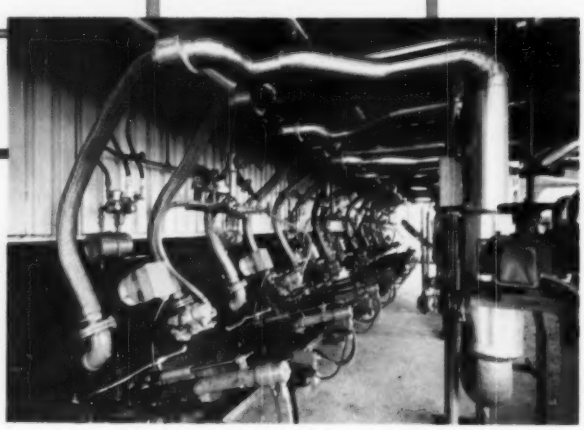
At the new North Lake Steam Electric Station the first of two Riley Turbo Furnace Reheat Boilers recently purchased by Dallas Power & Light Company is now on the line. Distribution of furnace gases is exceptionally uniform with minimum metal temperature variations across the full widths of reheater and superheater. Superheat and reheat temperatures are maintained over required control ranges. Boiler operates continuously at design rating for long periods. Extreme ease of operation with minimum operating personnel results from all burners being located for opposed firing on *one* level. Steam temperature is mainly controlled by automatic dampers located below the economizers.

Several other Southwestern Public Utilities have installed the Riley Turbo Furnace Boiler because its design and method of firing permits quick, easy and low cost conversion from natural gas to other fuels.

ENGINEERING DATA

Capacity — 1,200,000 lbs/hr
Pressure — 2125 psig
Superheat — 1005F,
Reheat — 1005F
Fired by Natural Gas, Oil

EBASCO SERVICES, INC.
Consulting Engineers

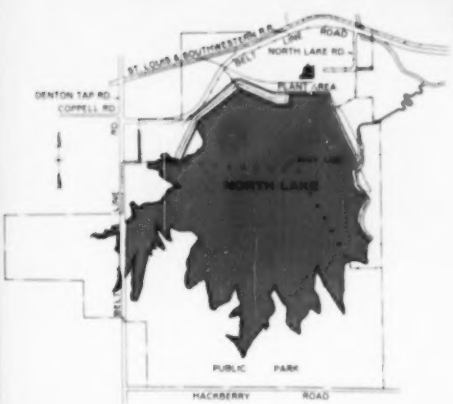


One of two firing aisles located on opposite sides of the furnace shows ten Riley Directional Flame Turbo Furnace Burners. The Turbo Furnace single level burner arrangement minimizes operating supervision and maintenance.

A careful survey of your plant by a qualified consulting engineer could show ways of making substantial savings in power costs.

Reheat Boilers will produce for *Dallas Power & Light Company*

NORTH LAKE STEAM ELECTRIC STATION



North Lake is an 800 acre man-made lake constructed for cooling water by Dallas Power & Light. Most of its area is open to public boating and fishing. Here is an unusual use of a private power company's facility. Much credit is due to Dallas Power & Light Company for imaginative and public spirited foresight.

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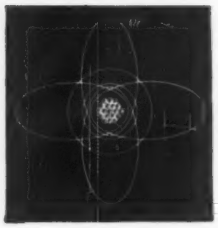


Nuclear notes

By B G A SKROTZKI, Associate Editor

Dresden Nuclear Power Station, first privately financed nuclear plant to go into operation, was dedicated on Oct 12, 1960 at its site about 50 miles southwest of Chicago, Ill. Dresden was built for Commonwealth Edison Company by the General Electric Company at a fixed price of $45 million. In addition, Commonwealth spent about $6 million for site and overhead costs. Nuclear Power Group members paid $15 million of the contract price to met R & D expenses. General Electric has not revealed the true cost for its part of the 180-mwe plant. Excavation started March 1957, construction was completed Sept 23, 1959. The first chain reaction was achieved Oct 15, 1959. First electricity was generated April 15, 1960 and full power on June 29, 1960. The plant went in commercial operation on Aug 1, 1960. The first 65 tons of 1.5%-enriched UO_2 fuel cost about $15 million and is expected to last for 3½ years. The operating crew of the plant will have 95 people.

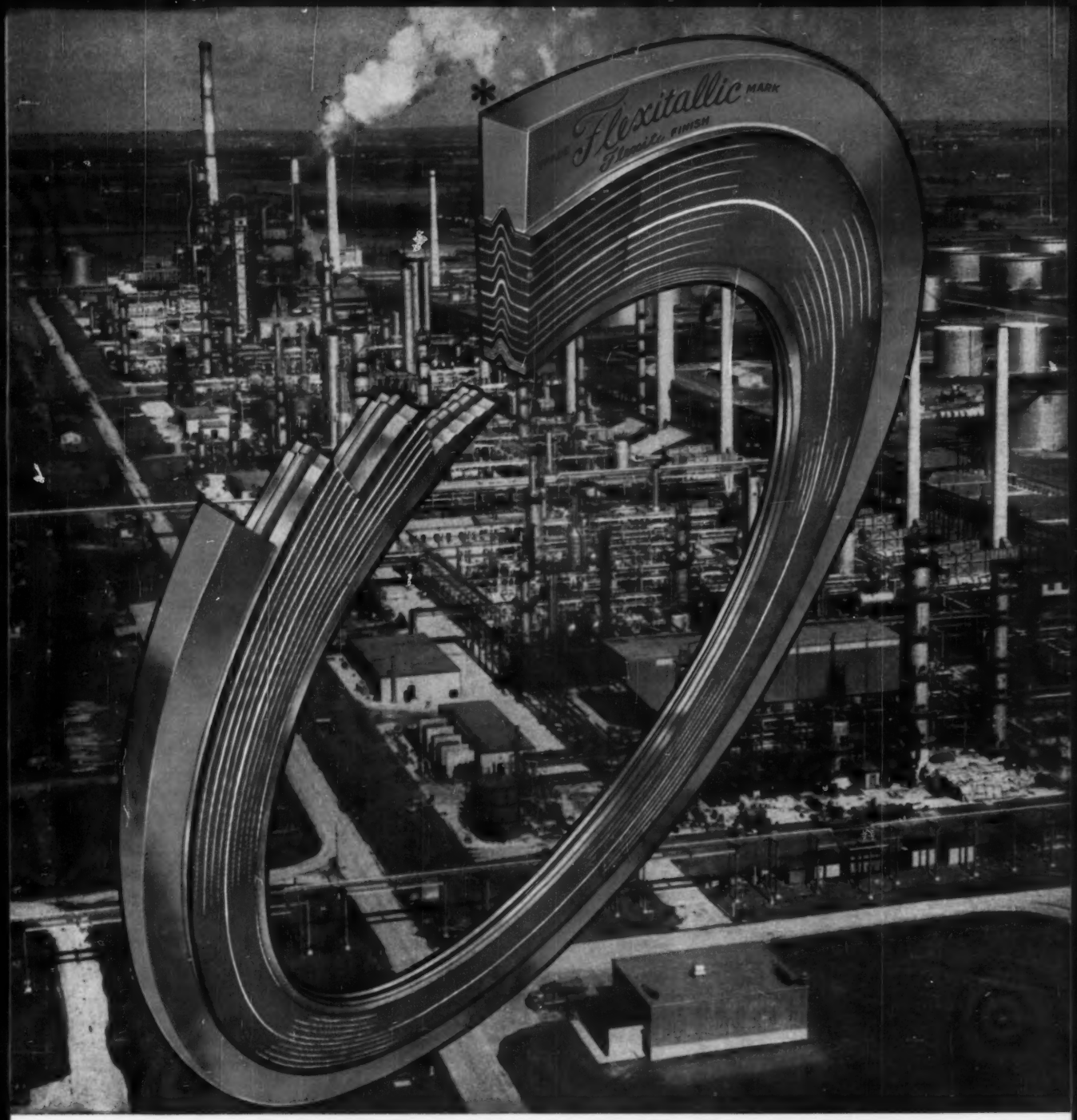
Uranium carbide offers promise of becoming an important fuel material because of its high uranium-atom density, good thermal conductivity and radiation stability. Herbert S Kalish of Olin Mathieson Chemical Corporation notes that one of the major problems centers on finding an economic method of fabricating the compound under good control. The product will have to hold given amounts of free uranium plus oxygen and nitrogen when made by cold pressing and sintering.

Atomic wastes will be explored as a fuel for thermoelectric generators by the General Instrument Corporation. This will be done for the AEC as part of the SNAP program (Systems for Nuclear Auxiliary Power). GI Corp will investigate the heat characteristics of the unrefined fission products of various AEC plants.

PM-3A nuclear plant for operation in McMurdo Sound in the Antarctic will be built by the Nuclear Division of The Martin Company under contract to the AEC. The plant will produce about 10 mwt for 1.5 mwe and 650,000 Btu per hr steam output. The plant will be built as 18 modules each measuring 8 ft, 8 in. x 8 ft, 8 in. x 30 ft. The pressurized-water reactor will allow local boiling in the hottest elements. The fuel will be highly enriched UO_2 in a stainless steel cermet. There will be about 29 kg of U-235 in the core with an expected burnup of about 9 kg. The primary loop will run at 463 F and 1300 psia. Secondary conditions will be 300-psia minimum steam pressure at full load. The turbine will run with 6-in.-Hg abs backpressure held by two direct-air-cooled condensers.

"Radioactive Waste Handling in the Nuclear Power Industry", a report of the Technical Appraisal Task Force on Nuclear Power, has been published by the Edison Electric Institute. While radioactive waste materials will be generated at nuclear plants, they will be removed and stored at spent-fuel recovery plants. The wastes will have to be contained for several hundred years and longer. Present holding methods appear economically acceptable; costs range about 1 to 5% of total nuclear power costs. There are no early prospects for using wastes as byproducts.

Molten-salt reactor will be built at the AEC's Oak Ridge National Laboratory in Tenn. The 10-mwt unit will run mostly at 5 mwt and dump its heat to atmosphere. The fuel is in solution with the salt making it possible to remove radioactive wastes continuously. The solution will develop about 1225 F and a mixture of lithium and beryllium fluorides will be used as the coolant. The plant is scheduled to start in spring 1963 and expected to cost about $4.1 million.



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For more facts circle 242 on Reader Service card, p 139

Reserved for your comment

BOB BELLAS, Associate Editor

Clear it with Henry

In behalf of the Industrial Gas Cleaning Institute, I'd like to express our sincere appreciation for George Edwards' interest and his advising POWER readers of our activities (*Maybe you can cut your cleaning bills*, Sept 1960, p 234). We feel that we have established realistic goals and, with assistance such as this article gives, we expect to attain them. With reference to Mr Edwards' note of our need for an Executive Secretary, we'd appreciate your letting POWER readers know that we have obtained the services of Joel Henry, who can be reached at 15 W 44th St, New York, N. Y.

D L DEVRIES, *Koppers Co, Baltimore, Md.*

EDITOR'S NOTE: POWER's *special report*, Air Pollution, *in this issue spotlights the increasing responsibility that engineers must shoulder in containing waste emission within certain limits. Air-pollution-control activity across the country may mean more restrictive legislation, certainly will ultimately mean capital expenditures for abatement equipment. Experience shows that in some cases industry has spent considerable sums on useless control equipment, because of pressure from the community and compounded by lack of a "feedbox" from which to draw expert help. It appears that the Industrial Gas Cleaning Institute can provide such a source of information as an aid to economical and efficient selection, installation of needed effluent-cleaning equipment.*

A novel approach

We received not a letter but a copy of a Spanish-language book the other day from a reader in the Argentine. Over the author's autograph, this inscription appears on the flyleaf: "To Steve Elonka . . . this modest emulation of his admirable and patient devotion to boiler-operator education."

We leafed through the book, before surrendering it to Steve for addition to the somewhat crowded trophy corner of his office, and our curiosity was aroused. We could tell from pictures of boilers (and a few words we recognized) that it obviously dealt with power-plant equipment. What stumped us were the drawings, very cleverly done, of people and pumps, valves, etc. This was obviously something apart from the run-of-the-mill boiler-room manual. On the dust jacket was a review written by Acis Greblow. This, translated by a friend on McGraw-Hill's El Automovil Americano, *is what Señor Greblow has to say:*

The Diary of a Stoker (Diaro de un foguista) is an interesting study in teaching, the result of vast experience and a profound knowledge of the subject matter, and of the sure belief in the need of putting in the hands of power-plant personnel a simple book that will clear up many doubts and arouse some interest.

The author, Engineer J Agrest, graduate of the University of Buenos Aires in 1934, belongs to the group of Argentine engineers who developed during the industrial growth of the nation and shared intimately in its problems. By temperament he belongs to the group that make their professional work their daily school and he loves to teach while learning and to learn while teaching.

The characters in his book are the real stokers that have shared many hours of struggle with him in the boiler room. The style and language are of the boiler room too, and therefore this *Diary* is not an elegant book. Many of its pages were written together with one of the stokers with grimy hands from coal or fuel oil. Rather than trying to achieve literary excellence, the author has tried to make sure that his book will be understood by the stokers for whom he wrote it.

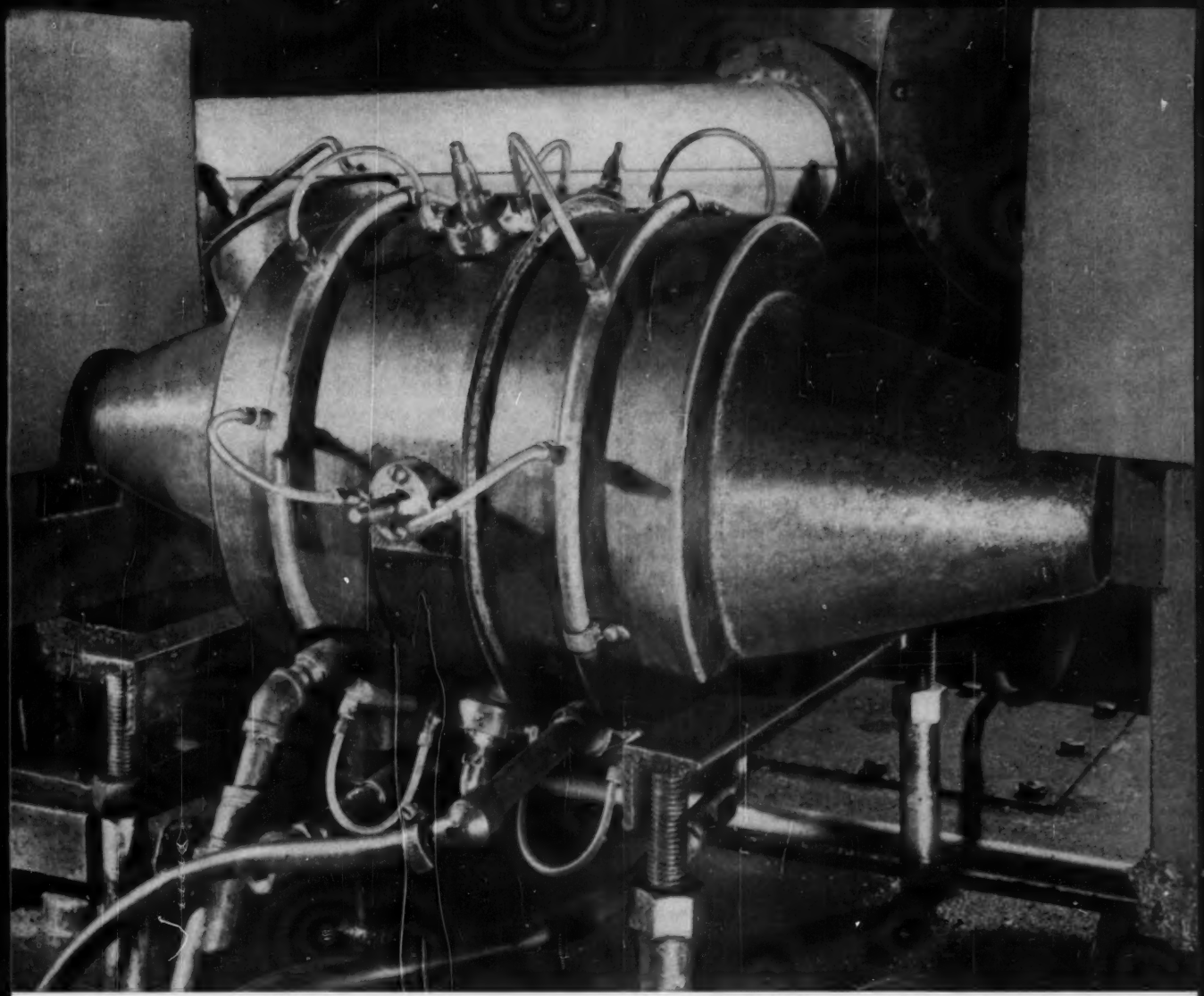
It has been said that sages are the people who are able to retain in their adult years the same curiosity that we all had when five years of age, and that we lose as we grow into maturity.

Antonio, the main character in this book, has the qualities that make sages. He is not satisfied with doing his exact duty; he wants to know *how* and *why*. His questions, his doubts, his thoughts and dreams form the basis of this book which achieves the difficult task of teaching while interesting the reader.

What, no asafetida?

I have fired a few boilers in my time and occasionally instruct a class in boiler operation. Every now and then my class will include an old-timer or two and I get a real kick out of listening to their experiences. One recently told me how he operated a battery of 500-psi oil-field boilers located in a swamp. He had nothing but swamp water to use for boiler feed and no way to treat the water. He found it impossible to keep the boilers from foaming, so each shift he'd slug them with turpentine. When he couldn't get turpentine, he'd open the manhole and throw a large, pitch-filled pine knot into the boiler. He said this worked just fine and he had never lost a boiler.

He asked if I had ever heard of this method of preventing boiler from foaming and when I said that I hadn't, he asked what I would have done to keep a normal water level in the gage glass under those circumstances. I couldn't come up with an



Here's where pressure tubing is wrapped in a protective fog

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USS National Seamless Pressure Tubes are safe. They are made by piercing a white hot steel billet of the finest steel. Rigid testing of each length of pressure tubing is added insurance against trouble.

For your next installation, consider USS National Seamless Pressure Tubing. It's stocked all over the country by National Tube Distributors. They can furnish helpful information on the use of USS National Seamless Pressure Tubing and give you speedy, efficient delivery. Our trained Mill Service Force is also available for field consultation by writing: National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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For more facts circle 243 on Reader Service card, p 139

answer. What would Marmaduke do in this case?

BURD ROHDE, *Las Vegas, Nev.*

EDITOR'S NOTE: *We couldn't locate Surfaceblow, so we passed this along to our good friend John Todd, who has been around a few boilers in his time, too. John says, "It is a known fact that many of the old-time engineers evolved homemade remedies for various boiler ills. As is usual, one learns of the successes but never of the failures. It is entirely possible that the use of turpentine, which is an organic compound obtained from pine wood, could have prevented the boilers from priming in this particular instance. However, it should not be assumed that this so-called treatment would be satisfactory in all cases as priming can be caused by various conditions.*

"It must also be realized that design and operating conditions of the present-day boiler are very much different from those encountered some years ago. It is extremely unlikely that any present-day engineer would have the temerity to attempt the use of homemade remedies such as turpentine, kerosene, potatoes, horse manure, pine knots, oak logs, etc to correct an unsatisfactory feedwater condition."

Not 'hyperbola', hyperbole

I was much interested in your article on hyperbolic cooling towers (Sept 1960, pp 67-72). Enclosed is a picture in which a cooling tower with a wooden shell can be seen, far left. The other two are the first European steel-reinforced concrete shells. Note the small circular openings at the base of the tower in the center, and the V openings of the one on the right which offer much less resistance to air flow. Height of the shell on the right is 118 ft and shell thickness is about 5 in. at the base, tapers to 1½ in. at the top. Notice also the excessive flare from point of minimum diameter to the top. This design was intended to gain draft as velocity decreased, but the idea has long since been abandoned.

For years all towers of the Dutch State Mines have been equipped with a splash fill of concrete bars instead of wooden ones. There is an essential difference between the splash fill and the water-film fill; heat exchange between droplets and air is quite different from exchange between a water film and air. The water-film design is also used by Balcke of Germany, and our latest towers are equipped with sheets of asbestos-cement.

You state that in n-d towers the water saturation, rather than heat, causes the change in air density. To me, this seems not quite correct. Air temperature above the fill is somewhat less than inlet-water temperature. We have made a considerable number of tests and have found differences of about 3.6 F with n-d towers.

The hyperbolic tower also can be equipped with a fan. We have three large towers, 77-ft base diameter, which have been changed to induced draft. Two newest ones have 41½-ft-diameter fans and the towers' hyperbolic shape has been altered. Each tower has a maximum load of 17,000 gpm.

Concerning your statement that n-d towers need far less space than i-d arrangements: we place our i-d towers on 120-ft centers. With large-diameter fans in the vena contracta and a higher admissible load of water per sq ft of fill, space requirement of i-d towers is even less.

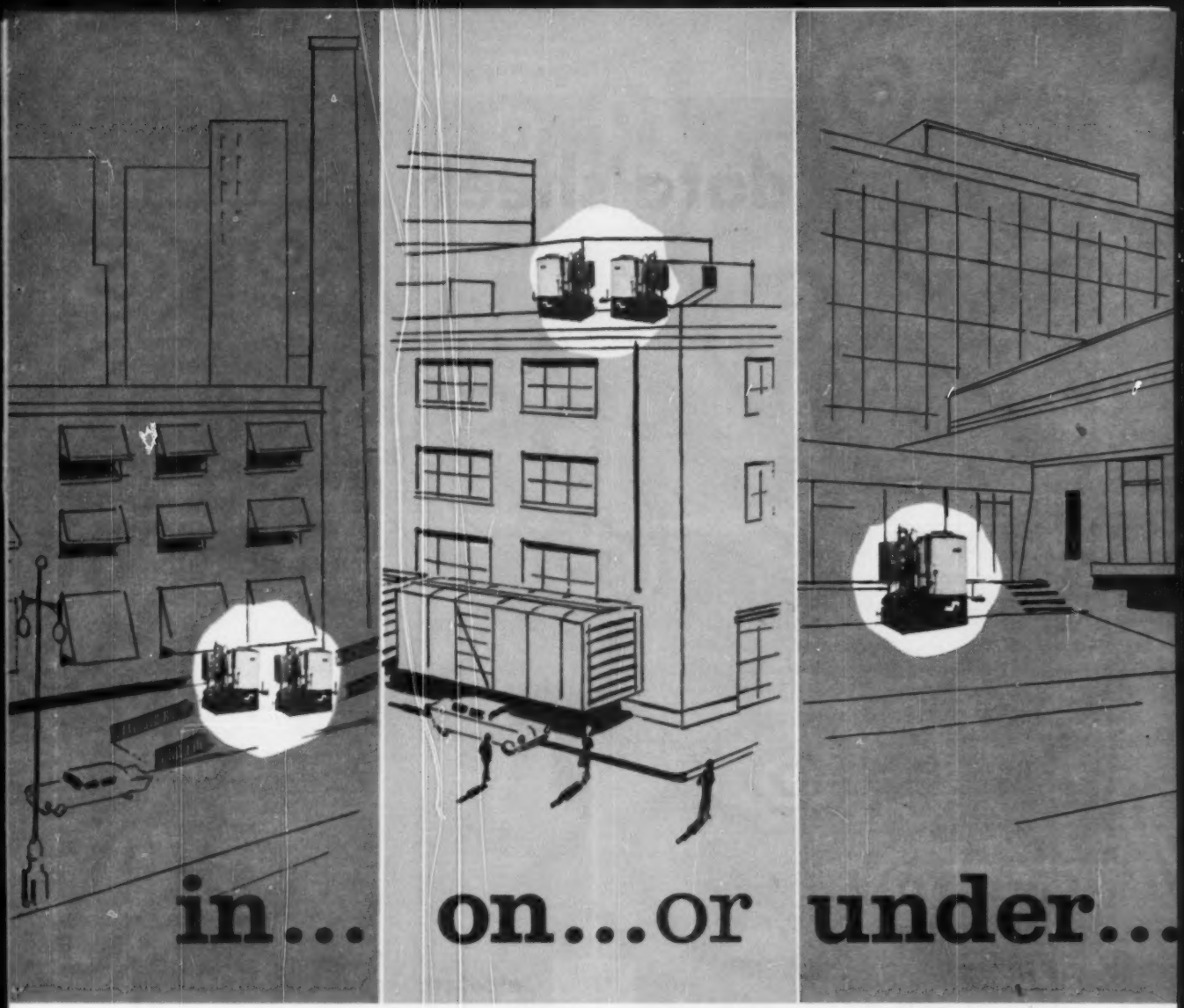
F W VAN BERCKEL, *Chief Engineer of Power Plants State Mines in Limburg at Heerlen, Netherlands*

EDITOR'S NOTE: *Reader van Berckel's letter and picture of the first reinforced-concrete hyperbolic cooling tower at Dutch State Mines are much appreciated. We agree that both fill material and construction are controversial subjects.*

He is right in questioning our statement, p 69, on water saturation relation to air density. Sentence should have read, "This is much like chimney operation except that water saturation, rather than just *heat, causes the change in air density."*

We can't agree, though, with his comment on space requirements. Let's assume the operating conditions for Kentucky Power's Big Sandy cooling tower: 245-ft diameter, 120,000 gpm. Tower area is then about 47,000 sq ft. Reader van Berckel's 77-ft towers on 120-ft centers handle 17,000 gpm each. So at least six towers would be needed, probably seven. Minimum land area required would be about 60,000 sq ft—about a 27% increase.

circle 244 on Reader Service card, p 139 ▶



Leading beverage company proves "Steam The Modern Way" saves space

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This, indeed, is "Steam the Modern Way"... a 175 HP Clayton takes just 4 ft. x 7 ft. of floor space, stands just 8 ft. high. Write for full information on how Claytons can solve *your* space problems.

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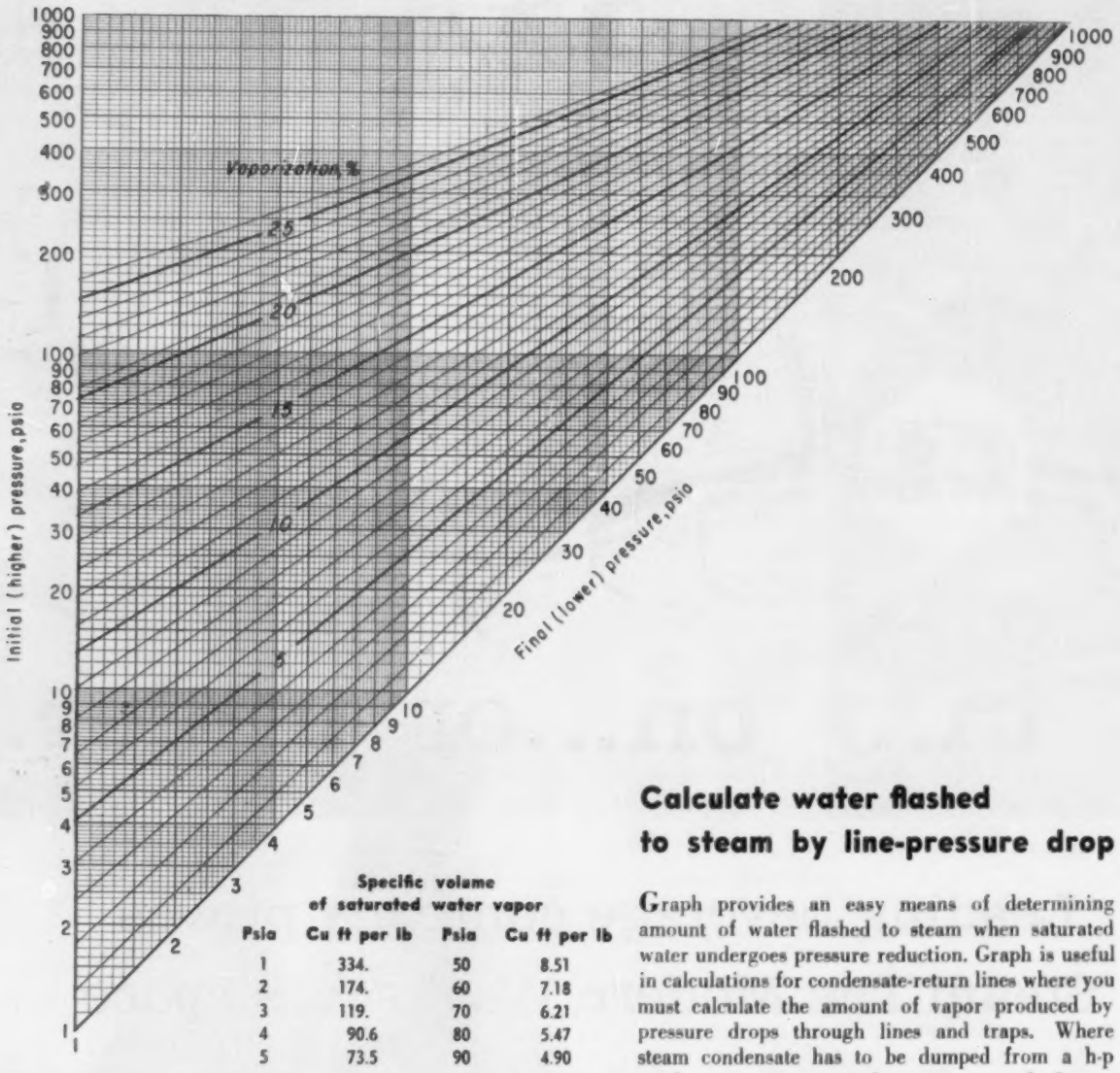
Power's data sheet

No. 340



Specific volume of saturated water vapor			
Psia	Cu ft per lb	Psia	Cu ft per lb
1	334.	50	8.51
2	174.	60	7.18
3	119.	70	6.21
4	90.6	80	5.47
5	73.5	90	4.90
6	62.0	100	4.43
7	53.6	120	3.73
8	47.3	140	3.22
9	42.4	160	2.83
10	38.4	180	2.53
15	26.3	200	2.29
20	20.1	220	2.09
25	16.3	240	1.92
30	13.7	260	1.77
35	11.9	280	1.65
40	10.5	300	1.54

Calculate water flashed to steam by line-pressure drop

Graph provides an easy means of determining amount of water flashed to steam when saturated water undergoes pressure reduction. Graph is useful in calculations for condensate-return lines where you must calculate the amount of vapor produced by pressure drops through lines and traps. Where steam condensate has to be dumped from a h-p condensate system to a l-p system, graph figures amount of vapor to be handled.

To use the graph, enter at left with higher pressure in psia and proceed horizontally to the right to vertical line corresponding to lower pressure. From diagonal lines read percentage of water flashed on weight basis. Table, left, permits calculation of volume for flashed portion.

Interpolation between diagonal percentage lines is accurate enough for most uses.

L A Richardson, *Oranjestad, Aruba, Neth. Antilles*

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Mr. Larry E. Day, Plant Engineer at Houdaille, ran a 30 day test with MOGUL endeavoring to eliminate the sludge problem and, at the same time, to operate the system at a higher efficiency. Results were so conclusive that MOGUL is now used in the entire dust collector system.

The Houdaille savings story is another outstanding example of the advantages in MOGUL-IZING – the *modern* method of water treatment technology.

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Technical briefs . . . Latest engineering

National Power Conference highlights computer control in central generating stations

The general philosophy and objectives of power-plant automation, *W L Chadwick, Southern California Edison Company*
A review of history and a look at today's needs forms a logical vantage point for appraising current computer-control status and predicting tomorrow's progress. In 1924 a new 10-mw control system had 27 inputs and 11 outputs. Southern California Edison's latest computer-controlled units —1165 inputs, 430 outputs—40-fold increase.

Need for better unit reliability and operation closer to material limits mothered this tremendous control-system growth. Outage tolerance by industry is almost nonexistent—40 years ago several interruptions per day (lengthened by somewhat leisurely corrective action) were not uncommon. Ever-rising fuel costs have forced heat-rate reduction through plant sophistication.

At Southern California Edison, cost of computer control can be offset by prevention of a cumulative 4½-month unit outage over its useful life. But decision to go ahead was based on the many benefits of computer control: (1) plant-investment safety (2) absence of panic (3) inhumanly rapid scanning (4) cost of accidents prevented (5) reduced operating labor (6) reduced maintenance through early trouble warning and (7) operating economy of closer unit supervision. *AIEE 60-1164*

Computer application to power-plant automation, *F V Lyle, Daystrom Inc*
Ten years ago computers were designed primarily for scientific calculations with strong emphasis on arithmetic computations. But application in power plants required other capabilities; the computer has to communicate with operators (information) and the outside world (control).

By dividing computer actions into these two classes, information and control, you can review them in detail as a step towards using their full capability. First, computer superiority to normal alarm systems is characterized by ability to scan much more quickly than humanly possible and to alter alarm limits in accord with changing interrelated operating conditions. In the control area, speed of response can increase efficiency, prevent accidents. Data-gathering service and heat-rate calculation by computers precludes human error.

This timely and detailed review of capability leads to better understanding, permitting fuller utilization of computers as power-plant control and operating tools. *AIEE CP60-1167*

The systems approach to a computer-controlled generating plant, *W M Gaines, L F Kennedy, A M Spielberg, General Electric Company*
Many individual steps must be taken in proper order to assure optimum computer-controlled-plant design and operation. First step is problem definition; station use plays an important part here. Anticipated peaking service makes automatic shutdown and startup essential. But in high-fuel-cost areas, station economy may be the prime need.

Since optimum design depends on many diverse skills, team approach to all phases of computer-control application seems best. Currently it is impossible to find all of these skills in any one organization, so the team must be made up of individuals from several firms—owner, engineer, equipment manufacturer.

From preliminary layout through equipment shop test, each step must be completely organized and thoroughly taken. Even after installation much work remains, including in-plant testing and modification to fully realize computer-control benefit. *AIEE CP60-1165*

The organization and management of automated power plants, *W T Hess, The Louisiana Power and Light Co*
Although Louisiana Power and Light's new Little Gypsy unit will be computer-controlled, capable of completely unattended operation, it can also be operated in the normal manner by station personnel. These two methods will give a direct comparison for evaluating computer-control benefits. But the unattended-operation requirement has undoubtedly forced automatic control of many little-used functions which might better be manually controlled in a later unit. And Little Gypsy, being the ultimate, will show clearly where it's profitable to back away from fully automatic control.

Cost of Little Gypsy's automatic control: about $630,000 over monitoring. But this is more than offset by reduction of major-accident probability —about 0.33 during the service life of a generating unit, costing as high as $4 million. Computer control provides a high degree of insurance against accidents by instantly making available, through prior programing, the best-possible thinking of engineers, operators and computer specialists to meet emergency situations. The computer will not panic, will not forget, will not reach for the wrong button. This assures a drastic reduction in normal generating-unit accident-probability figures. *La. P&L Co*

16 papers for you on:

developments for busy power men

STATION ECONOMY
ELECTRIC SERVICE
MAINTENANCE COATINGS

Automation . . . the application of computers to automatic boiler operation, *G W Kessler, The Babcock and Wilcox Company*
Boiler automatic control has been long with us; computer control is merely a further step—but a big one. No longer can power plants be broken down into sections with "our work ends here" signs around the periphery of each. Interrelations of power-plant components are greatly complicated by computer control. So coordination efforts between all involved, owners, engineers and equipment manufacturers, must increase vastly.

Operational safety with attendant reductions in maintenance, outage and possible personal injury, and operational-cost savings through increased efficiency and reduced manpower are the major benefits of automation. But these must be balanced against certain disadvantages—increased complexity, computer maintenance, as yet unknown reliability and increased equipment costs. And "weak links" which currently exist in computer-control equipment must be eliminated. This means more accurate, sensitive and reliable hardware and includes pressure switches, solenoid valves, flow measurers and gas analyzers.

Most significant recent advance toward boiler automation is the development of sensitive flame-monitoring equipment. But the best available is still relatively crude, and much more work is needed in this important area. *ASME 60-PWR-1*

Electric service

What utilities are doing to provide quality service, *L V Dugas and Y L Hughes, Gulf States Utility Co*
Through carefully worked out policies and practices Gulf States Utilities Co has helped attract many industrials to the booming Texas-Gulf-Coast area. In 1957 they were negotiating with 11 firms; nine of them built plants in the area served and now account for almost 200,000-kw contract power.

Industrials showed little desire to own their substations. They wished to avoid paying a specialized maintenance crew, and the return on investment was not attractive. To hold down costs, Gulf States Utilities has standardized industrial substation designs—one each for 15, 69 and 138 kv. Results: planned bulk purchasing, inventory reduction and lower construction costs.

Two power rates were specifically designed to meet industry needs, one for loads of 2500 kw and up, another for 20,000 to 90,000 kva. Extreme flexibility was intentionally built into these two rates so industrials can get the service quality they actually need at reasonable cost.

Peak load at Gulf States Utilities today runs about 1,200,000 kw; expected increase by 1965—another million kw. *AIEE CP60-1163*

Industry's need for quality electric-power service, *R W Worley, United Engineers and Constructors Inc*
Industry's electric-power needs are becoming more exacting with increased use of automatic machinery. Greater coordination of effort between utilities, industries, consulting engineers and equipment manufacturers is required.

Actual need for electric-power continuity must be established on an economic basis—it is not a good idea just to aim blindly for "highest possible," because this may well cost more than it is really worth. But some plant functions—computers are an example—really do need highest-possible continuity. You may find it profitable to deal with these functions separately to minimize high cost of overall plant electric service.

A lot of factors make up a complete standby-power study and some are pretty tricky. Experienced evaluation is a must to skirt the many pitfalls.

In-plant voltage and frequency regulation are sometimes glossed over during planning and construction stages. Yet careful attention to these details produces least cost. Remember—low voltage and poor frequency control can up operating costs and hurt efficiency by upsetting complex automatic machinery. They can shorten lighting-equipment life. *ASME 60-PWR-2*

Station economy

Turbine-exhaust losses, *C E Seglem and R O Brown, Westinghouse Electric Corporation*
Turbine-exhaust losses make up a considerable part of total fluid-dynamic losses in a steam-turbine cycle, running as high as 10% of all turbine-associated fluid-dynamic losses in a typical machine. Reducing these losses 25% makes possible turbine-heat-rate gains of 30 to 50-Btu per kwhr.

Terms are defined, factors affecting exhaust-hood losses covered, interrelationships explained.

Air-model hood-testing programs have produced configurations with considerably reduced hood losses, and traverse testing of new hood designs installed on low-pressure turbines confirms the air-model tests. Results: turbine-heat-rate improvements of 0.3 to 0.6%, depending on turbine-exhaust volumetric flow and design of original reference exhaust hood. *ASME 60-PWR-7*

Directions for ordering these papers on page 138

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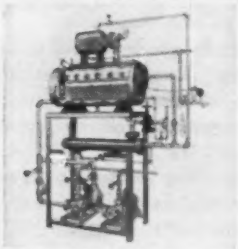

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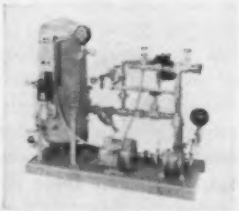

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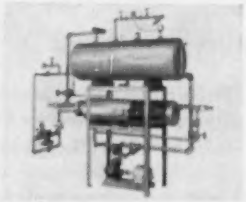

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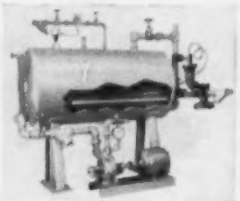

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Technical briefs

Maintenance coatings

Maintenance coatings — manufacturers' responsibility, *C G Munger, Amercoat Corporation*
Maintenance coating is not just a fancy name for painting, it means much more. Of course, ordinary paints are used in larger volume, but in critical areas maintenance coatings meet the special needs of adhesion, toughness, chemical resistance, weather, humidity and water. And manufacturers' responsibilities for maintenance coatings are necessarily increased because of these special properties.

Manufacturers must first know why ordinary paint fails in a certain environment. Only then can they decide which maintenance coating will do the job. They must carry out effective research programs in lab and field. Their representations to customers must be responsible—there just are no "cure-alls" in the maintenance-coating business. They must know and specify detailed application techniques.

Each of these responsibility areas is illustrated by specific case histories to clearly show its importance in the overall maintenance - coating picture. *NACE, Northeast Region, 1960*

The contractor's part in industrial maintenance coating, *L S Hartman, Hartman-Walsh Painting Company*
Wide experience with many past maintenance - coating jobs becomes available to plant owners when outside contractors do the job. They are maintenance - coating specialists — their equipment is up-to-date. They must produce quality work *at a profit* and yet still be competitive or they will shortly go out of business. All this adds up to savings for the owner, direct (first cost) and indirect (long maintenance-coating life).

Contractor's experience is available not only on the job but even before specifications are issued. He can base helpful suggestions to the plant owner on his work with many coatings in many environments. He knows degree of surface preparation.

Begins on page 130

needed to satisfy the owner and will not stake his reputation on poorly prepared surfaces.

Using a maintenance-coating contractor instead of your own plant maintenance force has other advantages too. It eliminates "make-work" programs and "rainy-day" schedules to keep plant force busy. In the long run these can be very costly. *NACE, Northeast Region, 1960*

Electrical distribution

Higher distribution voltages in industrial plants, *J D Wood and F Tamberrino, I-T-E Circuit Breaker Co*

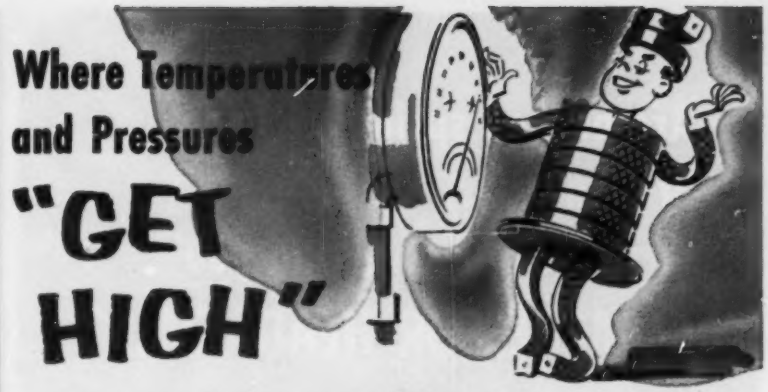
Higher distribution voltages in industrial plants is outgrowth of increased loads—largely due to air conditioning and automation. Large blocks of power are frequently needed in decentralized locations. Higher-voltage distribution systems reduce need for large bulky cable runs, and costs are less for 5- to 15-kva primary systems with decentralized unit subs. Flexibility and continuity of service are also increased.

Actual voltage selection depends on study of (1) types of loads (2) load use at decentralized locations (3) load distance from power supply and (4) voltages available from power company. Many factory-built electrical-control assemblies meet needs of high-voltage distribution systems in industrial plants. Much of this equipment and its proper application are detailed. *APC*

Determination of economical distribution-substation size, *J A Smith, General Electric Company*

Economic sub size is the point where total costs are minimized — sum of substation, subtransmission and primary-feeder cost. But this neglects important cost influences such as rate of load growth, time value of money and existing system—its expansion must keep pace with actual demand.

Study considers various load densities in a presumed residential zone —1000 to 32,000 kva per sq mi. In each case several distribution voltages are checked from 4.16 to 34.5 kv.



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Style No. 30 – a very dense braided asbestos packing, highly resistant to high pressures. For use against petroleum products at high temperatures and pressures.

Style HP-RC – a wrapped asbestos cloth packing with a resilient rubber core. For use on steam hammers, expansion joints, pumps and piston rods calling for high pressure steam, air and gases at temperatures to 600 degrees F.

Style HP-RB–for high pressure steam service up to 600 degrees F. Constructed with a core of accordion-folded asbestos cloth and a resilient rubber back, around which is wrapped a closely woven asbestos cloth jacket.

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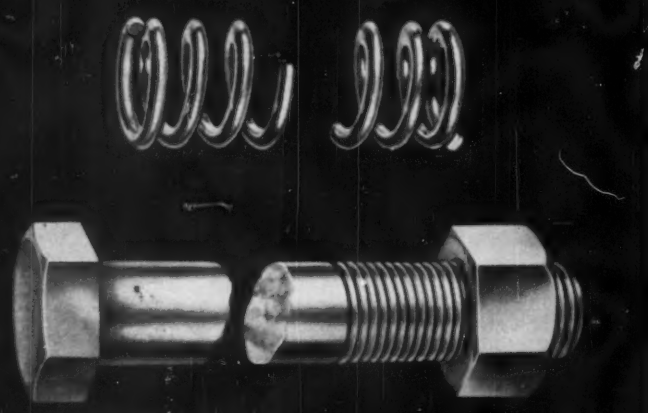

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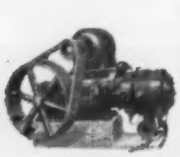

For more facts circle 248 on Reader Service card, p 139

Technical briefs

Begins on page 130

Factors tending to modify optimum sub size in either direction, depending on local conditions, are discussed. *AIEE CP 60-832*

Other energy-systems services

Corrosion of steam turbines and condensers in central - station power plants, *A B Sisson, Commonwealth Edison Company*

Corrosion studies of steam turbines and steam side of surface condensers have a common base in the steam-water mixtures handled. But problems differ with construction materials used in these two major power-plant components.

At Commonwealth Edison, units studied range from 5 to 325 mw, 300 to 2000 psi and 600 to 1050 F. So difficulties have run the gamut.

Corrosion problems with hardened valve stems and steam-turbine blading are detailed. And the corrosion-erosion phenomenon affecting turbine life is fully described. In most cases, material changes have minimized these difficulties.

Most condenser-tube failures, except in erosive environments, can be traced to the collection of dissolved gases—O_2 and NH_3. But redesign of air-removal sections to cut subcooling and use of stainless-steel tubes have gone a long way toward reducing steam-side tube corrosion.

Experimental use of aluminum condenser tubes at Commonwealth Edison is described. It is evident that better simulation of actual field conditions was needed for a better evaluation. *NACE, North Central Region, 1960*

Factors influencing the reliability of large steam-turbine generator units, *C D Wilson, Allis-Chalmers Manufacturing Company*

Reliability of large steam-turbine generators is the responsibility of *both* manufacturers and users. Only through proper attention to factors influencing reliability can long, satisfactory operating life be attained.

Factors affecting reliability fall into

A Nalco PRODUCT MANAGER

Answers Questions about Steam Condensate Systems Corrosion . . . and How to Control It

Costs of Equipment Repair and Replacement Can Be Cut Drastically with a Sound Control Program

James M. Seamon, Manager
Nalco Power Industry Chemicals Department

Industry still pays a huge annual bill for down-time, equipment replacement and repairs made necessary by steam condensate corrosion. Much of this cost can be eliminated by knowledge of what the problem is and action toward solving it. Here are answers to some basic questions that may be helpful to you.

Question: What does corrosion do in a steam condensate system?

Answer: Corrosion literally eats up the metal in the system from the inside. Piping, valves, pumps, and process equipment can be seriously damaged or ruined by corrosive condensate. Even boilers can be damaged by deposits resulting from metal oxides in corrosive returned condensate.

Question: What causes steam condensate corrosion?

Answer: Most condensate system corrosion is caused by carbon dioxide and oxygen, carried into the system with the steam. Carbon dioxide, dissolved in the pure condensed steam, forms corrosive carbonic acid. If oxygen is present with carbon dioxide, the corrosion rate is much higher, and is likely to produce localized pitting. Ammonia, in combination with carbon dioxide or oxygen, attacks copper alloys.

Question: What constitutes a corrosion prevention program?

Answer: There are three factors which should be examined in setting up a condensate corrosion-prevention program:

a. Softening, or other pretreatment of boiler feedwater should be designed to reduce the quantity of potential carbon dioxide that can be released from the boiler. Effective deaeration of feedwater also helps reduce oxygen content. Attention to both of these will make the final condensate corrosion prevention treatment more economical.

b. Mechanical design of the system should include such factors as maximum venting of corrosive gases, adequate velocities in lines, proper installation and maintenance of traps, and elimination of severe steam-impingement.

c. An effective chemical treatment program should be set up. Treatment may be either with a volatile amine chemical to neutralize carbon dioxide, or with a filming inhibitor which forms a protective barrier between the metal and the corrosive condensate.

Another important part of the chemical treatment program is continuous application of a fast acting chemical oxygen scavenger to the boiler feedwater.

Question: Can Nalco provide recommendations for a complete condensate control program?

Answer: Yes. Nalco will make a thorough survey and make recommendations for a complete corrosion control program.

Question: Which type of chemical treatment is best: volatile neutralizing amine or filming inhibitor?

Answer: This depends on the system to be treated. Plant layout and operating conditions, and the characteristics of boiler feedwater are some of the factors which should be taken into consideration. Generally, volatile amines are most desirable where low make-up volume, low feedwater alkalinity and good oxygen control exist. Filming inhibitors usually provide most economical protection in systems with high make-up, oxygen in-leakage, high alkalinity, or where the system is operated intermittently. In some plants, a combination of protective chemicals may be needed.

This is the area where Nalco know-how can result in thorough protection at minimum cost, by recommending a specific program to fit individual plant conditions.

Question: Isn't one condensate corrosion control chemical about the same as any other?

Answer: Definitely not. Both the volatile amines and filming inhibitors are complex chemicals—members of chemical "families" in which a nearly infinite variety of types is possible. Best treatment chemicals are those which offer the greatest protection in relation to their cost. Even though Nalco chemicals are now outstanding in results-per-dollar, Nalco research and development continues in order to improve this ratio.

Question: What help can Nalco provide in setting up and maintaining a condensate corrosion control program?

Answer: Your Nalco Representative has the technical training and experience to be of substantial assistance in setting up and maintaining an effective condensate corrosion control program. His service is backed by the facilities and experience of the entire Nalco organization. Where special problems occur, Nalco specialists are ready to help him find answers promptly.

Suggestion: Call your Nalco Representative, or write to me for further details on Nalco steam condensate corrosion control . . . or data on any aspect of modern water treating practices for better plant operating efficiency. James M. Seamon, Manager, Power Industry Chemicals Department.

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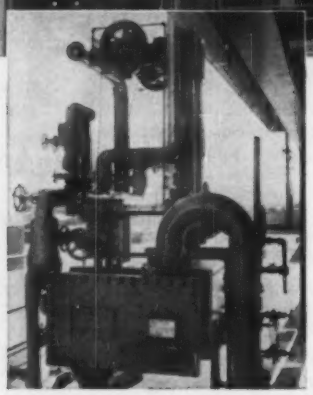
BURBANK CHOOSES SWECO CUSTOM-ENGINEERED POWER PLANT EQUIPMENT



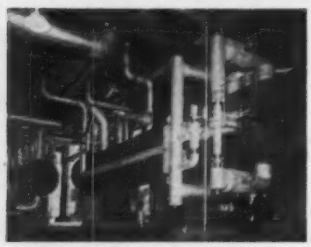
Steam Jet Ejector-Reboiler Inter and After Condenser Unit designed to remove ammonia and other non-condensibles from Burbank's ejector-condenser drains.

Surface Condenser, with 38,920 sq. ft. area and weighing 125 tons, condenses steam from 44,000 KW steam turbine-generator. Neoprene lining of water boxes, covers and manhole plates provides protection against corrosion.

One of the largest surface condensers shipped completely assembled was custom-engineered and constructed by SWECO for the City of Burbank, California. Performance efficiency is above customer specifications... Winkler tests show zero oxygen in the condensate from full to 27% load... less than 4°F. terminal difference is recorded at full capacity.

A SWECO Ejector-Condenser unit with patented reboiler removes non-condensible contaminants from ejector-condenser drains. SWECO Feedwater Heaters, too, are an integral part of Burbank's recent 60% expansion of power plant output.

Leading power engineers look to SWECO's broad experience in custom-engineering and manufacturing shell and tube equipment. Illustrated literature on SWECO power plant equipment is available; write to Dept. 15-393.



Feedwater Heaters, high-pressure all-welded type units, condense bleed steam and heat feedwater.

SWECO

Southwestern Engineering Company

4800 Santa Fe Avenue, Los Angeles 58, California
Engineers - Constructors - Manufacturers

For more facts circle 250 on Reader Service card, p 139

Technical briefs

Begins on page 130

five groups: (1) design (2) manufacturing (3) installation (4) operation and (5) preventive maintenance. Critical factors in each group are detailed and many hints included to help all involved cover essential points. *APC—1960*

Developments in maintenance welding, *W H T Svanoe, E I DuPont de Nemours and Company*

Some welding methods have a long history, but many more are quite new. Although they have been developed for production purposes, their application in maintenance must not be overlooked. Maintenance men should not be satisfied to stick with older welding methods when recently developed techniques could lighten their work load *and* do a better job.

Many old and new welding techniques are reviewed in this maintenance welding primer. Included are: oxyacetylene, electric-arc and both consumable- and nonconsumable-electrode, inert-gas-shielded welding. Metal-cutting methods and their specific applications are discussed.

Ready-trained welders are just not in plentiful supply. So industry must undertake suitable training programs to meet their needs. And retraining of experienced welders to acquaint them with new techniques is also a must. The day has passed when we can blithely turn over to a welder a new joint or material and rely implicitly on his ability to do the job right without instruction. *ASME 60-MPE-4*

Code testing of large boilers—input-output or heat-loss method, *J A Bostoc and W F Long, Cleveland Electric Illuminating Company*

Recent trends in boiler-testing-equipment provisions have emphasized need for refined testing procedures. Boiler-code testing, always a controversial subject, is being carefully re-examined.

Proposed new Code includes a change in efficiency definition and certain newly recognized heat losses. Latter include (1) sensible heat in the flue dust (2) heat in pulverized rejects (3) heat in cooling water. Using simulated test data, present and

THE MODERN TREND IS TO COAL

WITH DETROIT STOKERS* FOR ECONOMY OVER THE YEARS!

Increasing numbers of forward looking engineers recognize that coal is the most economical fuel over the long term, and that it can be burned most efficiently with Detroit Stokers.

Stability of price and lower cost in most industrial areas have made coal the most favored fuel in new plants being built today.

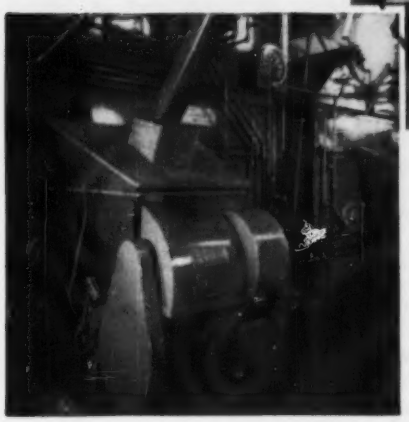
Detroit Stokers keep pace with this trend through continuous new developments and improvements that provide greater efficiency, easier operation and more economy.

Detroit Stokers are built for years of dependable service. Savings in fuel cost and maintenance continue to pile up long after the initial investment has been repaid.

This has been proved in hundreds of prominent Utility, Industrial and Institutional plants.

YOU can enjoy the benefits of modern, economical coal firing—Let us show you the Detroit Stokers best suited to your operating conditions.

Detroit RotoGrate Stoker—for boilers up to 400,000 pounds steam per hour capacity. A spreader stoker with forward moving grates which continuously discharge ash at the front.



*BETWEEN THE LOSTOKER AND ROTOGRATE STOKER IS A COMPLETE LINE OF UNDERFEED AND OVERTHROW SPREADER STOKERS FOR EVERY NEED.

Detroit LoStoker—capacity range 3,000 to 12,000 pounds steam per hour. An underfeed stoker of high efficiency—available with "start and stop" or "full floating control."

Detroit Stokers cost less: cost equals initial investment plus upkeep plus production losses due to equipment outage. The total is less with Detroit.

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DIVISION OF UNITED INDUSTRIAL CORPORATION

Main Office and Works, Monroe, Michigan • District Offices or Representatives in Principal Cities

for continued refrigeration dependability

INSIST ON GENUINE FRICK PARTS

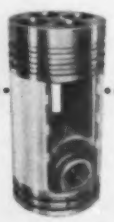
• Illustrated are eight points of superiority built into every Frick heavy-duty compressor.

We have been building all sizes of compressors for industrial and commercial refrigeration for more than 75 years. Some of our installations have operated 40 years without major repairs or replacements.

But when replacements *are* needed insist on genuine Frick parts to insure dependability.

FRICK COMPANY
WAYNESBORO, PENNSYLVANIA

TRADE FRICK MARK

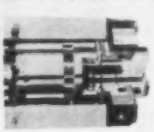


Pistons ground to size, with babbitt inserts for wearing surfaces. Standard oversized pistons stocked for prompt shipment.

Cylinder safety heads, held down by heavy springs, lift if slugs of liquid refrigerant or oil enter.

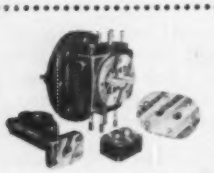
Die-cast bearings of best grade heavy-duty babbitt, surface-hardened against wear. Split sleeves make renewal easy.

Garland ring-plate suction valve; a superior design for handling suction gases at all pressures.



Frick patented Flexo-Seal holds pressure or vacuum around the shaft, to match your operating conditions.

Special Frick piston rings insure good compression and removal of excess oil.



Features of pressure oiling system include removable strainer, pump, gauge and one or more spring-loaded relief valves.

Case-hardened steel piston pins, accurately ground to fit bushings.

Technical briefs

Begins on page 130

proposed efficiencies for both input-output and heat-loss methods are compared—differences pointed up. CEI's Eastlake Unit 4 serves to illustrate these efficiencies in the practical application of both boiler-performance-testing methods.

New efficiency and newly defined losses are believed more realistic, but the end is not in sight. Efficiency difference between input-output and heat-loss methods still must be resolved. At present it is believed that the input-output efficiency is right; if enough work is done to find the additional unaccounted-for losses, they will show up not in the input-output but in the heat-loss efficiency. *ASME 60-PWR-5*

To obtain complete text

Material for these abstracts comes from the following sources. Order complete paper from source, **not** POWER.

AIEE. Contact American Institute of Electrical Engineers, 33 W 39th St, New York 18, N. Y. Members, 50c; nonmembers, $1.00.

ASME. Contact American Society of Mechanical Engineers, 29 W 39th St, New York 18, N. Y. Members, 50c; nonmembers, $1.00.

NACE. Reprints will be available after publication in *Corrosion.* Contact National Association of Corrosion Engineers, 1061 M & M Bldg, Houston 2, Texas. Prices not established.

La. P & L Co. A limited quantity of preprints is available from the author at no charge. Contact W T Hess, Vice-president, Louisiana Power & Light Co, 142 Delaronde St, New Orleans 14, La.

APC. Contact American Power Conference headquarters, Ill. Inst of Technology, Technology Center, Chicago 16, Ill.

"Make electricity work for you" will be theme of 1961 National Electrical Week observance, Feb 5 to 11.

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Either of the no-postage Reader Service cards below and p 139B will bring you information on any new equipment listed or product advertised, plus new literature for your files.

- **Study New Equipment** described in this issue starting on p 154. Circle numbers on card corresponding to items listed
- **Check New Literature** available this month beginning on p 139A. To get your personal copies use the card below
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New free literature

General equipment and key materials for systems engineering

- **Insulation and coatings**

101 **Heat transfer cements** for electric resistance heaters are explained in 4-p bulletin 600. Thermon Manufacturing Co

102 **Thermal-insulation master specification** covers fire-retardant materials. Copies of 27-p report are available from Insul-Coustic Corp

- **Metals and Materials**

103 **Alloy-iron properties** are charted in 8-p brochure 158. Centrifugally Cast Products Div of The Shenango Furnace Co

104 **Solving problems with silicones** is topic of reprint available from General Electric Company

- **Lubrication**

105 **Solid-lubricants booklet** has 24 pp, covers advantages of molybdenum-disulfide lubricants available in powder form, grease, resin-bonded coatings and variety of special forms. The Alpha-Molykote Corp

106 **Solid-film lubricant** for most types of metallic surfaces is described in 2-p bulletin. Hohman Plating & Mfg, Inc

- **Maintenance**

107 **Machinery vibration,** shock and noise are topic of 8-p bulletin K4G explaining 27 types of products for measurement and control. The Korfund Co, Inc

108 **High-speed balances** for small-capacity industrial-weighing operations are described in bulletin 3414. The Exact Weight Scale Co

109 **Utility car, "Scat,"** other applications for firm's engines ranging 4 to 24 hp are covered in booklet available from Kohler Company

110 **Cooling-tower-wood** deterioration, symptoms and suggested cures are topic of reprint 85. Nalco Chemical Co

- **Instrumentation**

111 **High-pressure flow** indicators and alarms for pressures up to 1500 psig are covered in 2-p

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Air-conditioning systems 142
Liquid-handling systems 142
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Electrical systems 148

bulletin 132. Brooks Instrument Company, Inc

112 **Temperature probes** are topic of 8-p booklet 66030. Rosemount Engineering Company

113 **Pressure instruments,** firm's complete line, are covered in revised catalog 40. Bailey Meter Company

114 **Solid-state electric control** systems producing variable outputs in accordance with desired or set-point conditions are illustrated in 4-p bulletin E74-1. Bailey Meter Company

115 **Remote-control code printer** for strip charts is described and illustrated in bulletin 136. Royson Engineering Co

116 **Static-control bulletin** GEA-6578A shows how static-control components simplify panel design and operation, has 8 pp. General Electric Company

117 **Operation recorders** are topic of bulletin describing and illustrating applications. The Esterline-Angus Company

118 **Ac pressure instruments** are explained with electrical, mechanical and dimension specs in bulletin S-604. Servonic Instruments, Inc

119 **Spectrophotometers** can adapt to requirements of such analyses as flame photometry, fluorometry, reflectometry. Details are in 14-p book 738. Beckman Instruments, Inc, Scientific and Process Instruments Div

120 **Thermal instrumentation** systems are covered in spec sheet S-690-1a. Sheet covers bulbs, tubing and fittings for filled-system thermometers. Minneapolis-Honeywell Regulator Co

121 **Thermocouple selector switches** are topic of 4-p catalog. Thermo Electric Co, Inc

122 **Receiver gages,** dial-indicating type, have range of 3 to 15 psi. Details are in 8-p catalog 530 available from United States Gauge Div of American Machine and Metals, Inc

123 **Computer service** for piping flexibility is introduced in booklet from The Service Bureau Corp

● **Heat exchange**

124 **Heat exchangers** for both steam-to-water and water-to-water heat transfer are described with

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NEW FREE LITERATURE continued.....circle key numbers, page 139, for your copies

engineering data, selection charts in well-indexed catalog 601. Old Dominion Iron & Steel Corp

● Prime movers

125 **Economics** of gas-turbine-power generation—detailed in comparative analysis of gas-turbine, steam and diesel generating plants. Clark Bros Company

126 **Fuel and oil additive** for prime mover and i-c engines is outlined in 6-p booklet. Lubrication Engineers, Inc

● Piping, valves fittings and specialties

127 **Valve catalog** contains all ordering information—cross-reference charts, weight tables. Data is in 20-p catalog 800 A available from Detroit Controls Div of American-Standard

128 **Hinged-closure** bulletin TT956 shows new design features, extended size ranges. Tube Turns Div of Chemetron Corp

129 **Pipe-fitters' manual** is comprehensive 72-p manual. Text, tables and illustrations give mathematical, physical, chemical and metallurgical data at a glance. Tube Turns Div of Chemetron Corp

130 **Check-valve** bulletin shows how to silence piping systems, eliminate line surges and water hammer. Combination Pump Valve Company

131 **Mounting tubing,** wiring, new techniques are featured in 76-p manual 212 G. Firm's clamps, brackets, shims and line supports are shown. TA Mfg Co

132 **Lubricated plug valves** are topic of four bulletins. Proper lubricant to suit valve service is featured in one section. Walworth Company

133 **Steel pipe** and tubing for h-t service are described in folder T-467. Data chart on 15 widely used steels is included. The Babcock & Wilcox Company

134 **Transite pipes** for plant fire-protection systems are asbestos cement; detailed in 8-p well-illustrated booklet TR-253A. Johns-Manville Corp

135 **Wire-mesh filter assemblies**—over 225 items of 20 basic types—are covered in 32-p bulletin. Data sheets list standard units and describe optional installations and applications. Pall Corp

136 **Flexible hoses** for conveying gases, solids and fluids are described in 20-p catalog ID-100D. Specs, applications, coupling recommendations are included. Universal Metal Hose Company

137 **Welded steel tubing,** fabricated or semifabricated, comes in five different steels, shown in 4-p folder 6759. Armco Steel Corp

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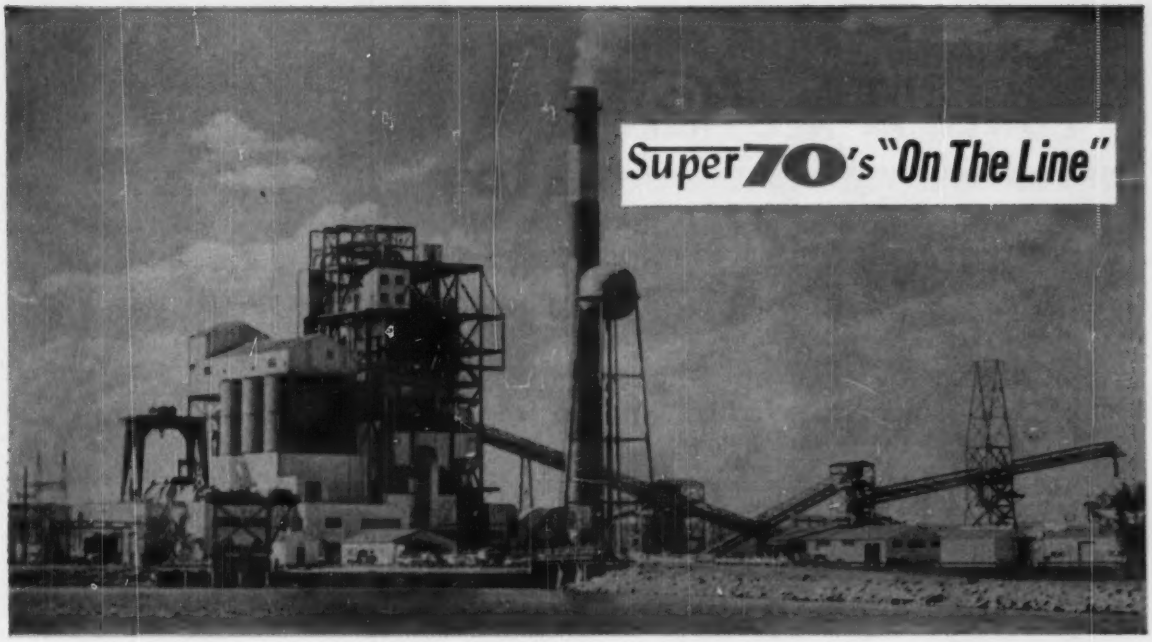


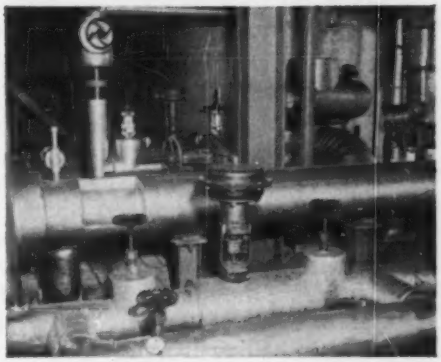
New Pioneer Along The "Old Oregon Trail"

Within sight of the "Old Oregon Trail" near the town of Glenrock, Wyoming, rises a new monument to Wyoming's modern era of industry and progress. It is Pacific Power & Light's new $23-million Dave Johnston steam-electric plant which boosted Wyoming's total electric power supply by one-third.

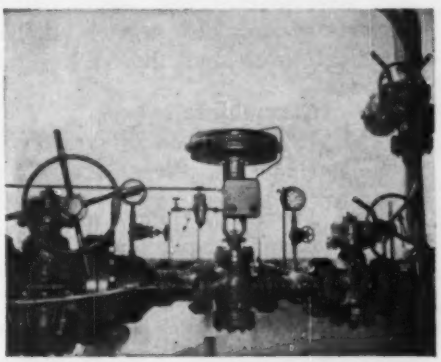
Engineered and constructed by Ebasco Services Incorporated, this ultra-modern plant utilizes BS&B Super 70 Diaphragm Control Valves, Pressure Controllers, Liquid Level Controllers and Transmitters for many vital roles in the plant's operation.

In the forthcoming No. 2 Unit of this plant, BS&B Controls will again render proud service to the Power Industry.

BS&B Controls are becoming renowned throughout the power industry for their superior performance characteristics and rugged dependability under widely varying operating conditions. Why not specify them for *your* next plant project? For detailed information, contact your nearby BS&B Controls Representative, or write directly to...



Evaporator Feedwater Level Control Valve



Plant gas supply is reduced from 400 to 150 psig by this Super 70 Pressure Reducing Valve and Controller.

BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

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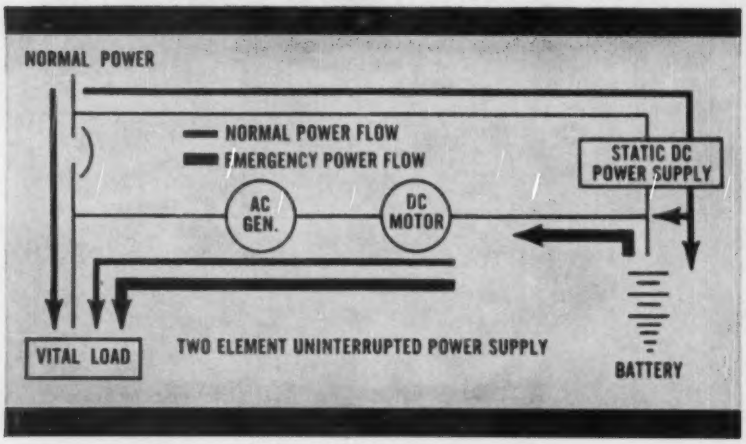
Kearfott Uninterrupted Power Systems...

FOR CONTINUOUS, UNVARYING POWER AT ALL TIMES



Typical applications: *Nuclear Reactors • Power Distribution • Digital Computers • Process Control • Communication Systems*

Kearfott Uninterrupted Power Systems are vital in applications where any interruption in AC power can cause serious loss or delay. These continuous power systems, which can be tailored to a variety of requirements, put an end – once and for all – to the problem of varying or intermittent prime power.

In one representative system arrangement, an AC generator is driven by a DC motor which derives power from a regulated rectifier in parallel with a long-life storage battery. When power fails or varies the rectifier, which normally supplies power to the DC driving motor, is disconnected and the battery provides surge-free power to the motor–*in zero time*. When prime power is restored, the system automatically reverts to standard operating conditions and the battery is restored to readiness by the main battery charger.

Also available in 2 and 3 unit systems operating in parallel with or isolated from the line, Kearfott's compact uninterrupted power systems also provide audible and/or visual alarms to indicate over- and under-voltage, overload or ground conditions.

Generator ratings to 150 KVA 60 and 400 cycles, single and polyphase.

Frequency, voltage, and transfer regulation as required by the application.

For complete data on the wide variety of arrangements available, write to:

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Free literature

Begins on page 139A

138 **Seamless welding fittings** and flanges are featured in 8-p brochure FB-502A. Carbon, alloy and stainless steels are covered. The Babcock & Wilcox Company

139 **Silicate insulation** for pipe and block are covered with heat-transmission data, physical and thermal characteristics, sizes and thicknesses listed. Details are in 6-p booklet 6472. Philip Carey Mfg Company

140 **Packing catalog** 60 includes service - recommendation chart, application and construction data. 22 pp cover packings for every service. Packaging info speeds ordering and selection. The Belmont Packing & Rubber Company

141 **Solenoid valves,** electromagnetic control are discussed in folder VS-51. Valves are 2-, 3- and 4-way. Automatic Switch Co

Air-conditioning systems

142 **Leak detection** for air-conditioning and refrigeration service is topic of 10-p bulletin GEA-6827A. Halogen leak detector and accessory equipment are featured. Quantitative measurement of leaks is described in detail. General Electric Company

143 **Unit heaters,** blast heaters, radiators are featured in 42-p catalog. Construction features, installations, specs and dimensions are detailed. Cutaways and diagrams aid selection. D J Murray Mfg Co

144 **Water-cooled condensers** for refrigeration and air conditioning, mechanically cleanable, are topic of 8-p bulletin WC-200. Halstead & Mitchell Co

145 **Air filter** uses single sheet of synthetic plastic material, breaks air stream into little jets, traps dust and dirt. Story is in 4-p bulletin available from American Air Filter Co, Inc

146 **Dust-control equipment** is discussed in 12-p catalog 271. Dry centrifugals, wet collectors, fabric collectors and electrostatic precipitators are included. American Air Filter Co, Inc

Liquid-handling systems

• **Water conditioning**

147 **Water softeners** are treated in folder 760 explaining how a softener works. Specs are given. Commercial Chemical Products, Inc, Water Softener Div

continued

For more facts circle 256 on Reader Service card, p 139

circle 257 on Reader Service card, p 139 ➤

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Ankorite "O" rings provide effective sealing through a range of pressures, temperatures and movements. When properly applied they exert low running friction on moving parts.

They offer many advantages:

1. Production cost is reduced by elimination of complicated assemblies.
2. Special assembly tools are not necessary.
3. Economical to use since only one "O" ring is required on piston or rod.
4. Long life, fluid-tight packing is assured with correct design and machining of grooves and mating parts.

Anchor has developed standard compounds to resist the actions of fluids such as air, gas, oil and chemicals over a wide temperature range. For more specialized applications, a wide variety of compounds is available. Data on sizes, etc. available on request.

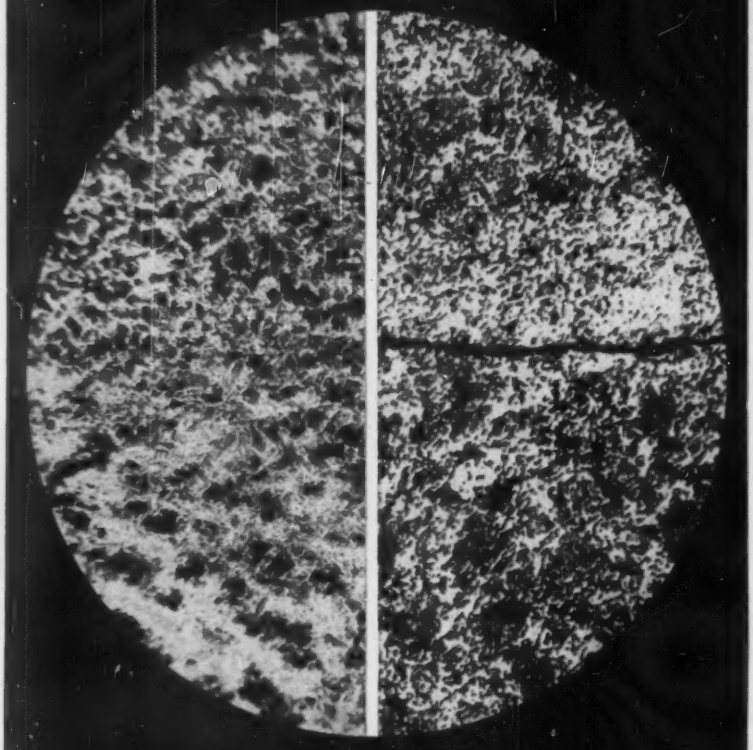
Find it Fast in the Yellow Pages

THE ANCHOR PACKING COMPANY

GENERAL OFFICES PHILADELPHIA, PENNSYLVANIA
FACTORIES MANHEIM, PA. ELKHART, IND. MONTREAL, CAN.

● FIBROUS AND METALLIC PACKINGS FOR EVERY INDUSTRIAL PURPOSE

why TRU-WELD is a stronger, better grating



photomicrograph of grating welds

This enlargement of the weld area in TRU-WELD grating shows how solidly the metals have joined. Cross bar and bearing bar have fused into a strong, moisture- and vibration-proof weld.

Enlargement of an incomplete weld area. Note the line of separation between bearing bar and cross bar. Heavy traffic and vibration can easily separate such a weld.

Tru-Weld grating is stronger because it is *made* that way. Its added strength comes from a manufacturing process that completely fuses the metal at cross bar-bearing bar joints and holds the bars to exact spacing. The result is grating that stands up under excessive vibration, heavy traffic or in areas where corrosive fumes and moisture are a problem. And Dravo Tru-Weld grating *costs no more.*

Complete estimating, layout and fabricating services are available. Immediate delivery from stocks maintained at nearby Joseph T. Ryerson Service Centers will help you meet exacting construction schedules.

For more information on this new, stronger grating, call the Dravo representative in your area, or write DRAVO CORPORATION, PITTSBURGH 25, PA.

DRAVO

CORPORATION

For more facts circle 258 on Reader Service card, p 139

Free literature

Begins on page 139A

148 **Varieties of process-water** treatment are explained in catalog 360. Boiler feed, chemical and waste treatment is covered. Commercial Chemical Products, Inc

149 **Return-line corrosion** is discussed in water-conditioning data sheet available from Betz Laboratories

150 **Slime control** with chlorine and nonoxidizing biocides is topic of data sheet from Betz Laboratories

• Pumps

151 **Volatile-liquid pumps** are featured in folder including cross-section drawings, illustrated applications of short-coupled and canned type vertical turbine pumps. Layne & Bowler, Inc

152 **Centrifugal pumps,** single-stage split-case type, are announced in sheet 150-V. Capacities range to 6000 gpm, heads to 380 ft. The Aurora Pump Div of The New York Air Brake Company

153 **Multistage centrifugal pumps,** opposed-impeller type for hot or cold water, hydrocarbons, chemicals, acids, condensates, handles medium-pressure boiler-feed service, hydraulic driving. Story is in 4-p bulletin available from Pacific Pumps, Inc

154 **Vacuum-diffusion-pump** catalog gives basic descriptive info on diffusion and booster pumps, shows speed curves for small, medium and large models ranging from 1 to 22 in. NRC Equipment Corp

Gas systems

• Air compressors

155 **Compressor** with 10,000-hp rating has maximum working pressures from vacuum to 15,000 psi. Operating characteristics, specs are given in 4-p bulletin 99. The Cooper-Bessemer Corp

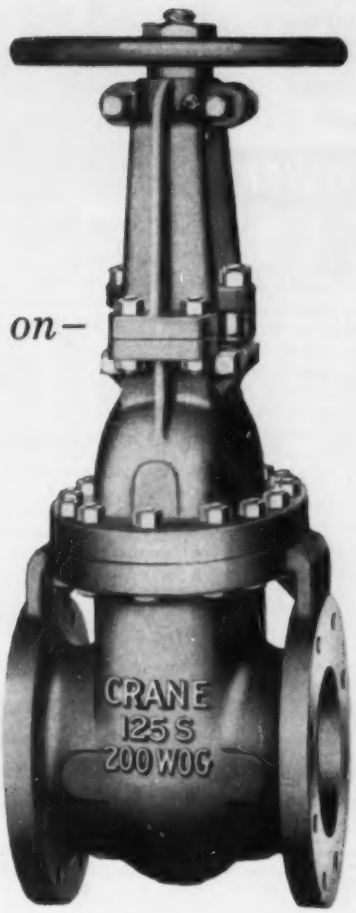
156 **Compressor, 4000-hp rating,** is topic of brochure 98 available from the Cooper-Bessemer Corp

157 **Operating characteristics** of 200- to 1000-hp compressor is featured in 4-p brochure 96. The Cooper-Bessemer Corp

158 **Compressor** has 400- to 1500-hp rating, maximum working pressure from vacuum to 15,000 psi. Details are in 4-p catalog 97. The Cooper-Bessemer Corp

continued

The valves most plants rely on–



No. 465½,
125-pound iron body
gate, bronze trimmed.
Sizes 2" to 48".

CRANE 125-POUND IRON BODY GATES

On general utility services . . . water mains and distribution lines . . . low-pressure steam and hot water . . . air and gas . . . more plants rely on Crane No. 465½ iron body bronze trimmed gates than on any other valve in this class.

Crane iron gates are an up-to-date design with service-proved features. A two-piece, ball-type packing gland for bind-proof packing adjustment . . . shoulder-type seat rings that won't loosen . . . extra-long disc guides to minimize drag on seating faces. All features are carefully planned to yield long, dependable operating life.

To enable you to standardize on these economical, efficient valves, Crane builds them in a full range of sizes. Popular sizes are available from local stocks of your Crane Distributor.

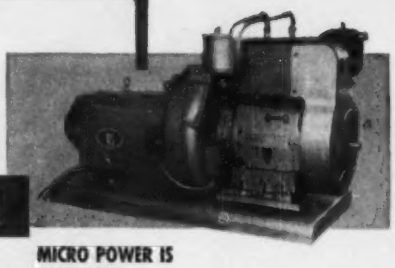
CRANE®

Crane Co., Industrial Products Group, 4100 S. Kedzie Ave., Chicago 32, Illinois

VALVES • ELECTRONIC CONTROLS • PIPING • PLUMBING • HEATING • AIR CONDITIONING

For more facts circle 259 on Reader Service card, p 139

DOUGLAS AIRCRAFT
TULSA DIVISION . . .
assures effectiveness of its protective boiler flame controls with . . .



MICRO POWER

In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, this is achieved with MICRO POWER.

At Douglas Aircraft in Tulsa, Micro Power serves as the dependable rear guard to the boiler room. It provides a constant source of steady, independent electrical power as required by the safety controls, thereby eliminating voltage fluctuations and protecting against power failure.

MICRO POWER IS ALSO USED . . .

- on microwave systems for communications, for remote control, for telemetering.
- for refinery and chemical process indication and control.
- by public utilities through microwave for protective relaying, telemetering and load distribution.

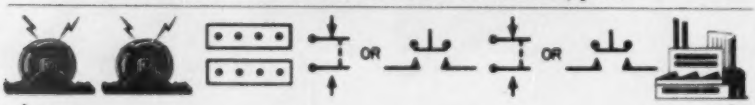
MICRO POWER PROVIDES . . .

- a constant uninterrupted source of electric power.
- voltage and frequency at usable value during transfers between motor and engine.
- stable voltage output.
- flywheel starting — no storage batteries.
- electrical isolation from commercial source — voltage dips, peaks and breaks do not affect microwave equipment, no transfer switch.

For complete information on this and other Micro Power applications, write . . .

UNITED STATES MOTORS CORPORATION
107 W. 5th Avenue · Oshkosh, Wisconsin

For more facts circle 260 on Reader Service card, p 139



TAKE THE LOAD OFF MAKING LOAD DISTRIBUTION CHARTS ...WITH CHART-PAK TAPES!

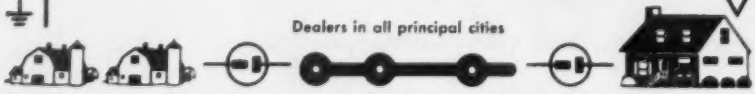
Chart-Pak tapes save you hours of drawing drudgery. You don't ink-in or paint lines, bars, shapes and symbols. You tape them on . . . fast . . . with Chart-Pak pressure-sensitive tapes and sheets!

Corrections are easy with Chart-Pak, too. There's no such thing as a mistake you can't fix . . . a change you can't make. If a line or symbol is in the wrong place, you can lift it up and replace it where you want it.

DON'T DRAW IT...TAPE IT WITH CHART-PAK

Write for free folder — "Visualization Made Easier."
CHART-PAK, INC., 201 River Road, Leeds, Mass.

Dealers in all principal cities



For more facts circle 261 on Reader Service card, p 139

Free literature

Begins on page 139A

- **Application**

159 **Compressed-air filters** for pneumatic instruments and controls, air-operated equipment of all kinds is featured in 8-p catalog 6000. Maximum flow rates range from 20 to 200 standard cubic ft per min. King Engineering Corp

160 **Air-drying units** for pneumatic systems, packaged type, are topic of 2-p bulletin 9100. Hankison Corp

161 **Pneumatic control** for temperatures up to 1800 F is introduced in 2-p bulletin 151-1. Burling Instrument Company

Mechanical transmission systems

162 **Speed drives,** motion and stationary control types, V-belt drives, pulleys, couplings, firm's complete line of mechanical-power-transmission equipment is outlined in well-illustrated catalog 23103. T B Wood's Sons Co

163 **Speed reducers,** parallel-shaft type, are featured in 36-p book 2719. Firm's expanded and redesigned balanced-design equipment in 57 sizes, capacities to 2800 hp is covered. Link-Belt Co

164 **Planetary-gear transmission,** shaft-mounted differential unit with capacity through 60 hp, is featured in 8-p bulletin LR-60. Airborne Accessories Corp

165 **Belts,** endless-woven-flat type, are detailed in bulletin available from Arthur S Brown Mfg Co

Steam and hot-water systems

166 **Storage hot-water tanks** to 6570 gal, heating elements to 33,000 gpm are topic of 8-p price and data catalog BH-2N. The Sims Co

167 **Steam converters** for steam heating water are covered in 20-p file 1460. Charts aid selection. Dunham-Bush, Inc

168 **Packaged steam generators** with automatic operation, capacities ranging from 20 to 600 hp, are outlined in 18-p catalog AA-2760. Low-pressure air-atomizing oil burner is covered. Ames Iron Works, Inc

- **Materials handling**

169 **Belting** catalog has 36 pp, gives specs, info on firm's line of conveyor, elevator and transmission belting. Cross sections show

the only complete line to handle every pipe movement problem!

Wherever there's pipe movement . . . thermal growth . . . vibration . . . there's a Flexonics product to absorb, guide, or control it.

Flexonics Corrugated Expansion Joints are expertly engineered to your needs, hydraulically formed, metallurgically treated by exclusive techniques, for maximum cyclic life. **Flexonics Expansion Compensators** offer the lowest-cost way, inch for inch, to absorb thermal growth in pipes or tubing 3" and smaller. **Flexonics Flexible Connectors** absorb vibration, permit random movement in pipes up to 24". **Flexonics Pipe Alignment Guides** and Roller Pipe Supports provide better guiding than old-fashioned methods, yet they cost less. **Check and mail the coupon today.**

EJMA **Member Expansion Joint Manufacturers Association**

EJ-259

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

Flexonics Corporation
1301 South Third Avenue
Maywood, Illinois

Please rush me complete information on

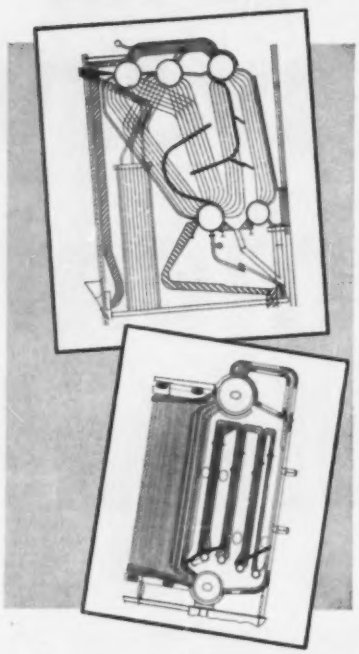
- ☐ Expansion Joints
- ☐ Expansion Compensators
- ☐ Flexible Connectors
- ☐ Pipe Guides and Supports

For more facts circle 262 on Reader Service card, p 139

ONLY ENCO BAFFLES

give you all these

COST CUTTING FEATURES



These important fuel-saving maintenance-reducing features are obtainable with Enco boiler baffles—*and only with Enco baffles.*

- **Streamlined gas flow**
- **Uniform gas flow**
- **Elimination of bottlenecks**
- **Reduced draft losses**
- **Higher heat transfer**
- **Cleaner heating surfaces**
- **Less use of soot blower**
- **Special provision for expansion**
- **Easy tube replacement**
- **Adaptable to any water-tube boiler, fired by any fuel**

Each application is designed on the basis of more than a quarter century of experience in this specialized branch of power engineering. Installations are made by skilled mechanics.

THE ENGINEER CO.

75 WEST STREET, NEW YORK 6, N.Y.

In Canada: Rock Utilities Ltd., 80 Joan Talon St. W., Montreal, P. Q. EC-506

circle 263 on Reader Service card, p 139

Free literature

Begins on page 139A

belt construction. Boston Woven Hose & Rubber Div of American Biltrite Rubber Co

170 **Automatic coal scale** is topic of 8-p reference bulletin 0359. Engineering and 3-dimensional drawings, dimension sheets are given. Richardson Scale Co

Electrical systems

- **Generation and transformation**

171 **Dry type transformers** are covered with prices, dimensions, specs in 24-p brochure GEA-6907A. Single- and 3-phase general-purpose, buck-boost and voltage-stabilizing transformers are included. General Electric Company

172 **Starters** and starter generators —75-, 100-, 200- and 400-amp sizes—are detailed in folder. Performance curves given. Breeze Corporations, Inc

173 **Substation transformers,** liquid filled, are topic of 18-p bulletin 5800-1A. Range for single- and 3-phase models is 501 to 10,000 kva and up to 69 kv. I-T-E Circuit Breaker Co

174 **Furnace transformers** with high current ratings are pictured internally and externally in 16-p booklet PFT3M960. Pennsylvania Transformer Div of McGraw-Edison Co

175 **Transformers** and substation equipment are detailed in brochure 960. Gives info on load-center and substation, transformers rated up to 10,000 kva, voltages up to 15 kv. Insulation, capacity, sound levels are covered. Sorgel Electric Company

- **Distribution and protection**

176 **Plastic control cable,** small-diameter type for conduit, duct, tray, direct burial in wet or dry locations is detailed in 4-p bulletin 1140. The Okonite Co

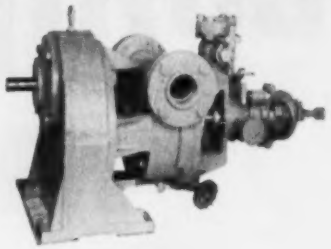
177 **Conduit,** cable seals, insulating bushings, cable supports and terminators are cataloged in bulletin A-460. The Adalet Mfg Co

178 **Wiring-installation** equipment is featured in 16-p catalog 159-D. Wireways, fittings, enclosures designed to JIC and NEMA standards are covered. Keystone Mfg Co

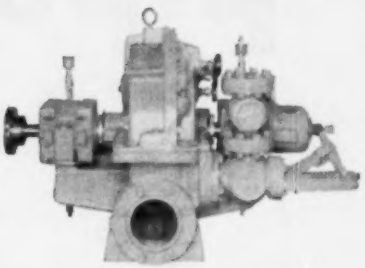
179 **Adjustable pulse switch,** center neutral limit switch, proximity switch are outlined in 4-p folder 84. Minneapolis-Honeywell Regulator Co

CARLING

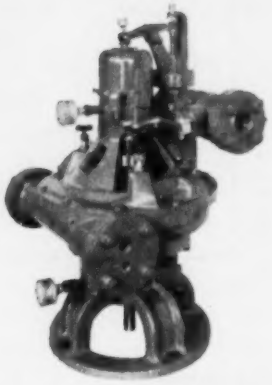
For 40 Years



the Quality Name



in TURBINES



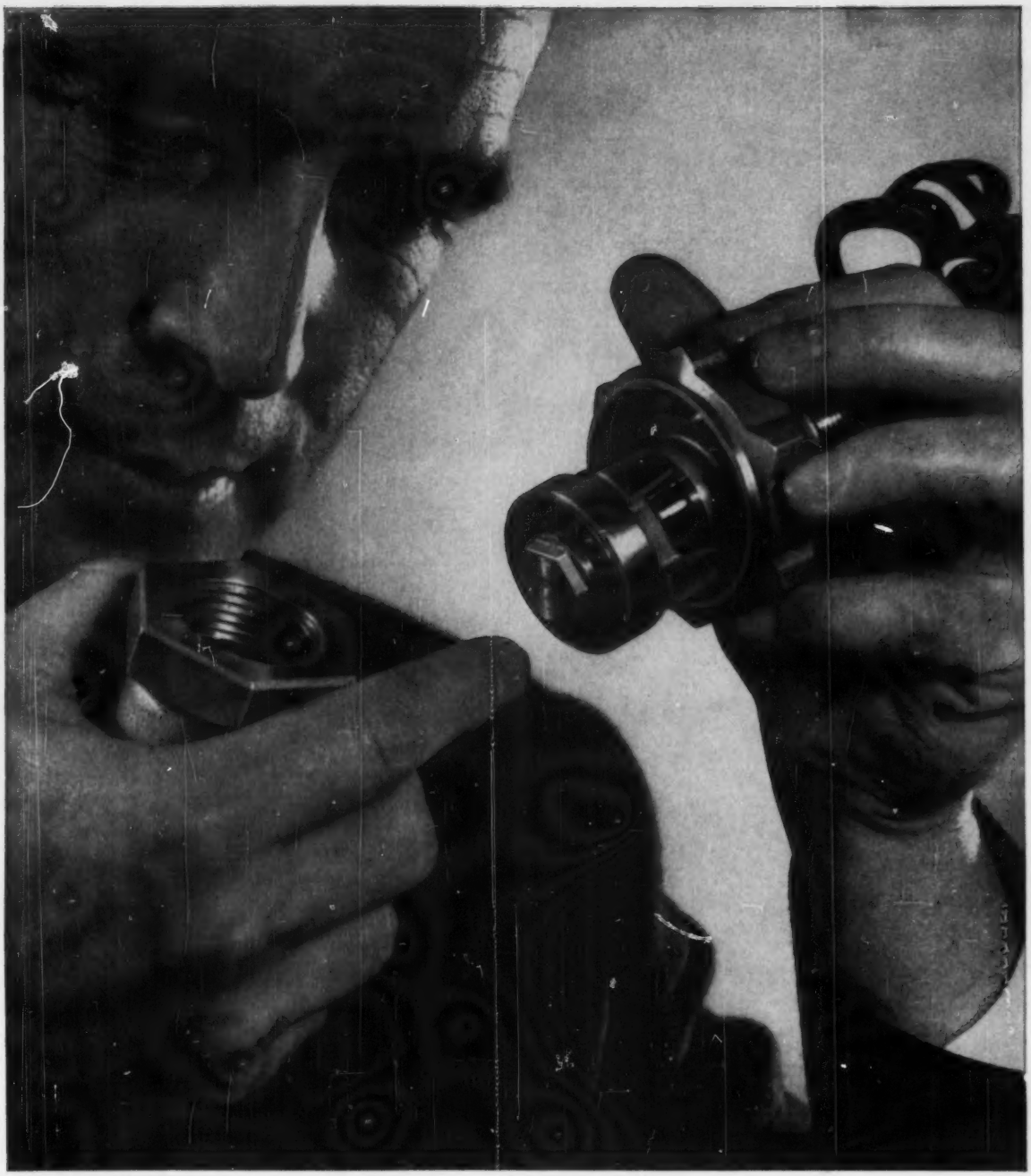
WRITE FOR BULLETIN 20—C-3

CARLING TURBINE BLOWER CO.

7 NEBRASKA ST., WORCESTER, MASSACHUSETTS

Representatives in Principal Cities

circle 264 on Reader Service card, p 139



MEN WHO KNOW VALVES look for the free-swiveling disc holder—know it keeps disc from grinding on seat, chops maintenance costs, assures leak-proof closure. It's an O-B feature—one of many improvements you get by standardizing on the complete O-B bronze valve line. Ask your O-B distributor for the valve in the orange-and-black box.

OHIO BRASS COMPANY • Mansfield, Ohio

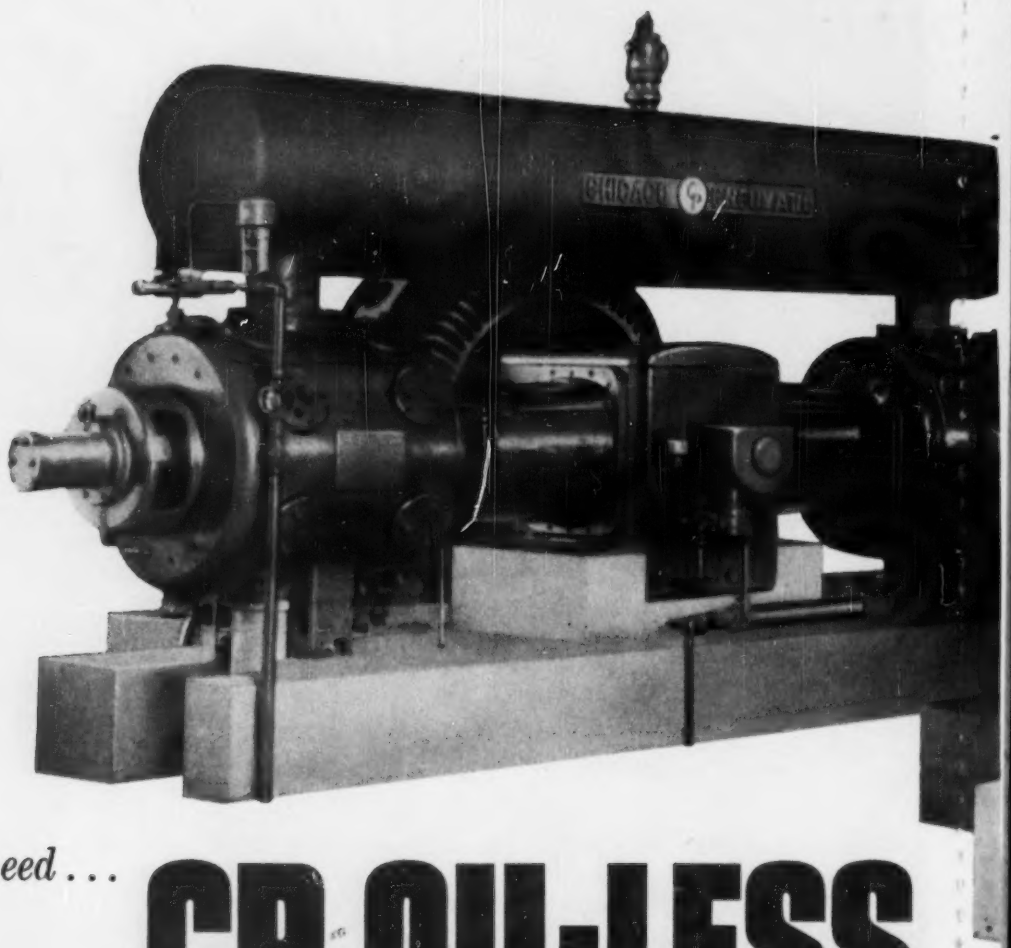
O-B VALVES

B HOLAN

10072-V

For more facts circle 265 on Reader Service card, p 139

If your process requires oil-free air or gas,



you need . . .

CP OIL-LESS COMPRESSORS

Where air must be oil-free, CP offers a choice of three basic designs of Oil-less Cylinder Compressors . . . your assurance of the "right" construction for all service conditions. CP Oil-less Cylinder Compressors can be furnished with tailrods and outboard crossheads to fully support the pistons on all horizontal compressors; distance pieces between cylinder and frame to insure the *absolute* in oil-free air; and a choice of carbon or Teflon* rings and packing.

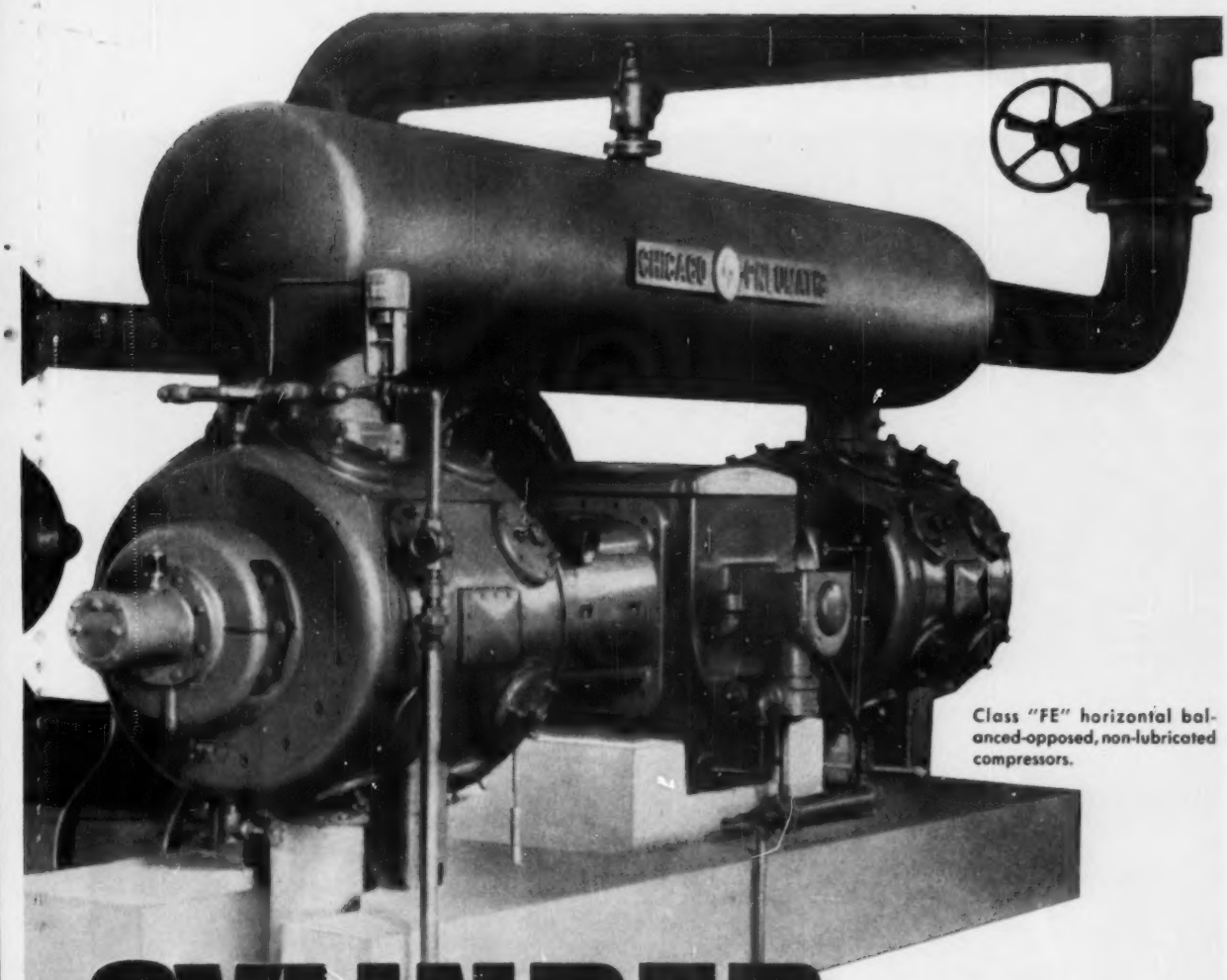
*T.M. of du Pont

For complete information, write:

Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, New York.

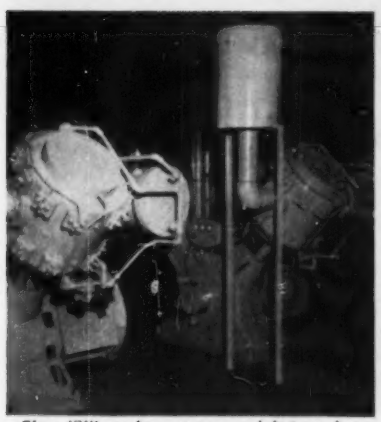
Chicago Pneumatic

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC AND ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

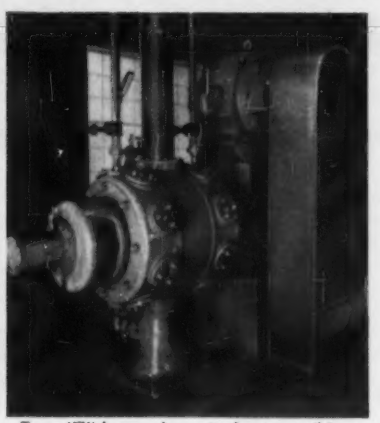


Class "FE" horizontal balanced-opposed, non-lubricated compressors.

CYLINDER



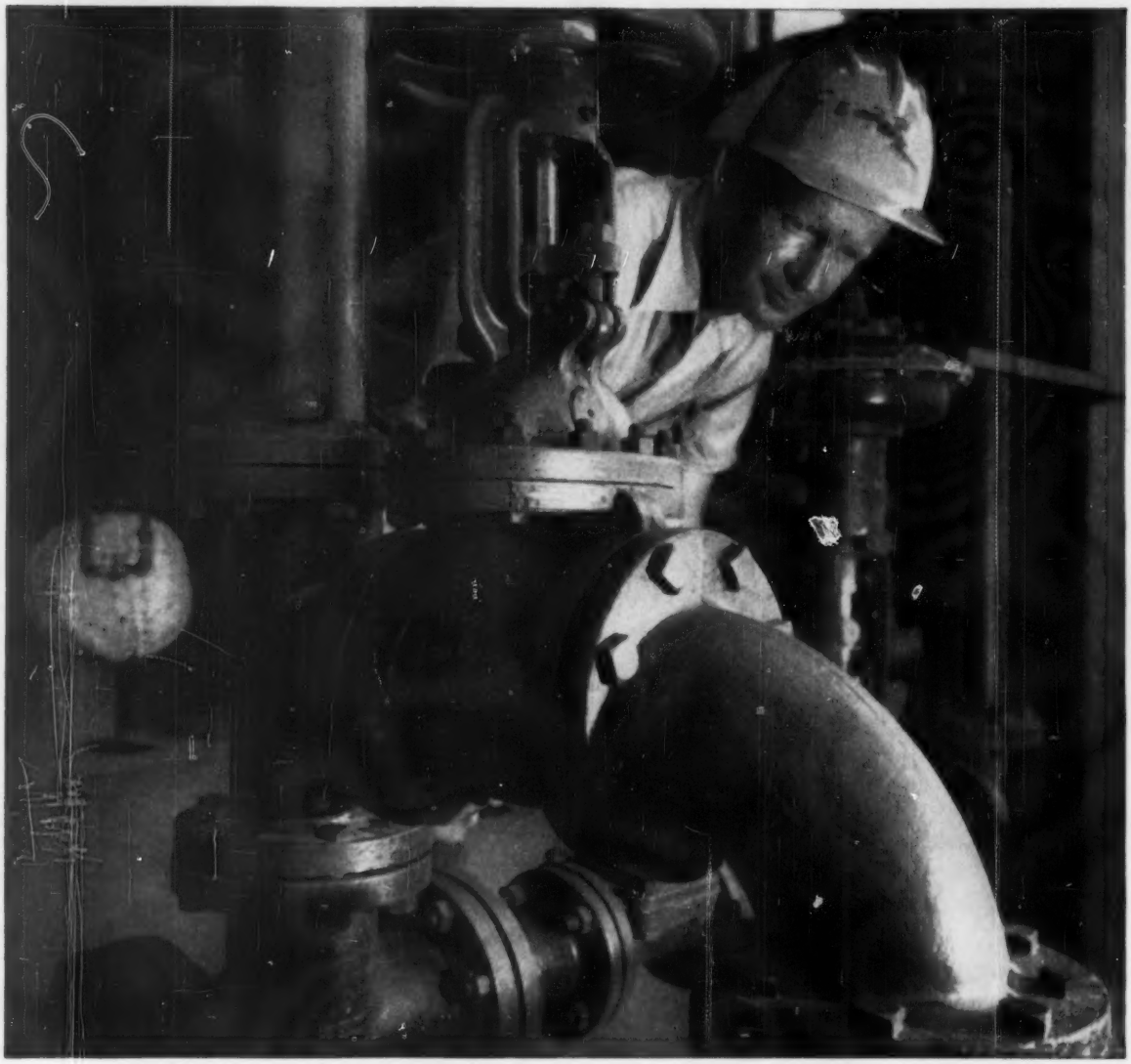
Class "Y" package type non-lubricated compressors.



Type "T" heavy-duty, single-stage oil-less cylinder compressor.

For more facts circle 266 on Reader Service card, p 139

DOW | **SARAN LINED PIPE**



"Hungry" water starves in Saran Lined Pipe

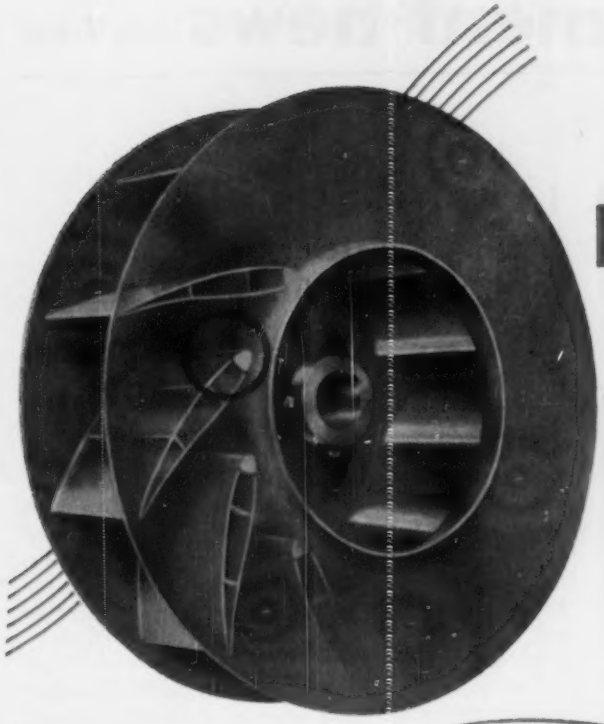
Steam turbines require water so pure that processors call it "hungry" — it absorbs impurities from any iron pipe that carries it. These metal contaminants in turn clog the turbine blades, can increase fuel cost as much as 12%. But Saran Lined Pipe travels the "hungriest" water from source to turbine without adding impurities, without corrosive pipe wear. For an example . . .

Gulf States Utilities Company's year-old Roy S. Nelson Power Station at Westlake, Louisiana, designed and constructed by Stone & Webster Engineering Corporation, produces over 200,000 kilowatts for residential, commercial, industrial and agricultural uses. This plant uses 2800 feet of Saran Lined Pipe to move acid and caustic treated well water for purification prior to steam conversion. Its battery of softeners and demineralizers produces 400 gallons of chemically pure water per minute.

Projected studies indicate, in spite of the action of caustic, sulphuric acid and the 120°F. water temperatures, the use of Saran Lined Pipe will reduce pipe replacement by 50%, while protecting the turbines from impurities.

Whenever dependable piping systems are required, whatever the degree of corrosion or chemical activity, consider Saran Lined Pipe. Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200°F. They're easily cut, fitted and modified in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 2502DW12.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN



COSTS HELD DOWN WHEN

® INLAND

INCLUDED

Green Airfoil Fans

IN FURNACE REBUILDING

At their #2 plant in East Chicago, Indiana, Inland Steel completely rebuilt and enlarged their furnaces to increase production. These rebuilt furnaces called for greater induced draft capacity in the waste heat boilers. The old fan installation of 7 Green radial blade fans had been installed 24 years ago.

Inland Steel replaced these 7 Green fans with 7 Green AIRFOIL induced draft fans. No changes were made in the original motors or electrical system. The 7 Green AIRFOIL fans took care of the increased draft requirements without overload on the original 125 hp motors.

In short, the new Green AIRFOIL fans made it possible for Inland Steel to increase the size and capacity of their furnaces without the expense of new motors and electrical installations in addition.

The Green AIRFOIL design provides smooth airflow with a minimum of turbulence. For longer life, the AIRFOIL fan blades have specially designed cast steel nose pieces to reduce wear. (See circled nose piece in illustration.)

If you have a tough job for heavy duty fans, it makes sense to talk over your problem with Green.

Green

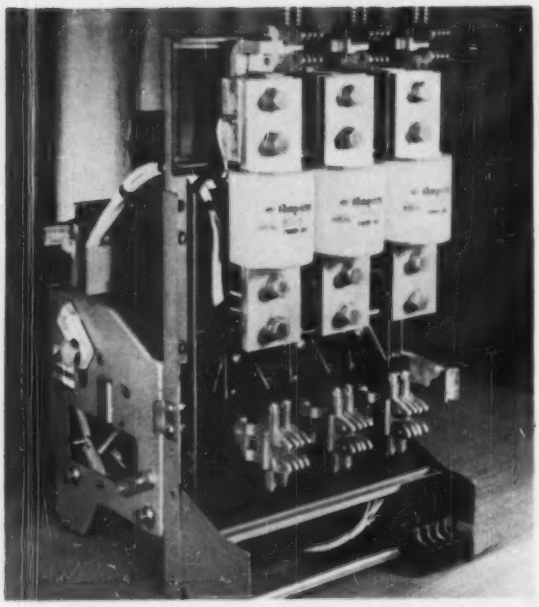
THE GREEN FUEL ECONOMIZER CO., INC.,

BEACON 3, NEW YORK

For more facts circle 268 on Reader Service card, p 139

For more data on these developments, circle key numbers on Reader Service card, p 139

Plant equipment news... Your



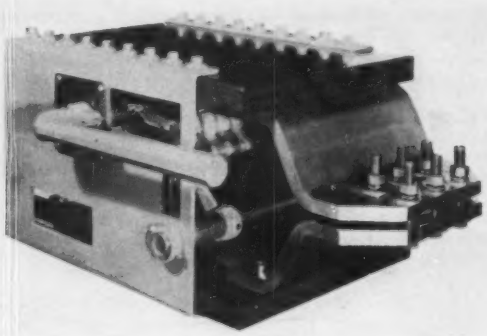
CURRENT-LIMITING FUSES mount safely on rear of circuit breaker. They're inaccessible until breaker is withdrawn from compartment. Closed-circuit contact with fuses is impossible

L-v current-limiting breakers protect against fault currents to 200,000 amp

1 • In a single switchgear compartment, circuit breaker integrates high-capacity current-limiting fuses, protective features of stored-energy breakers, device preventing single phasing. According to maker, current-limiting insurance doesn't sacrifice breaker's ability to adjust smoothly for overcurrent and short-circuit tripping.

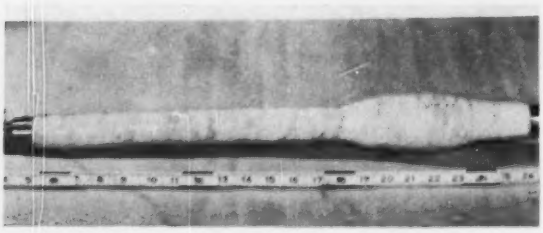
Application possibilities for this equipment are numerous. Maker suggests: replacing existing breakers when available short circuits exceed breaker interrupting capacity because of system expansion; protecting panelboards with limited interrupting capacity; protecting l-v bus duct, other load-side equipment with limited short-circuit-withstand capacity.

Current-limiting action is key to breaker's high-capacity fault protection. Fuses interrupt short-circuit current in less than a cycle, prevent its reaching a dangerous magnitude. Fuses take over protective function up to 200,000 amp from any preselected point—and they will not blow below that point. Interlocking arrangement prevents closing breaker until blown fuses are replaced. —I-T-E Circuit Breaker Company



Use l-v high-current disconnect switch in 5000 amp or multiples

2 • Suitable for 750-v operation, switch comes in both single-throw and double-throw designs. Apply it for gang operation in multiples of 5000 amp. Unit works effectively in a differential tinning line where switches bolt directly into buswork without other means of support, maker says. Design features: self-aligning copper contact wedges for good wiping action on closing and opening, positive backup springs for constant high pressure, locking type handle and copper cross sections for lower resistance.—H K Porter Company, Inc



Kit helps make hermetic oil seals

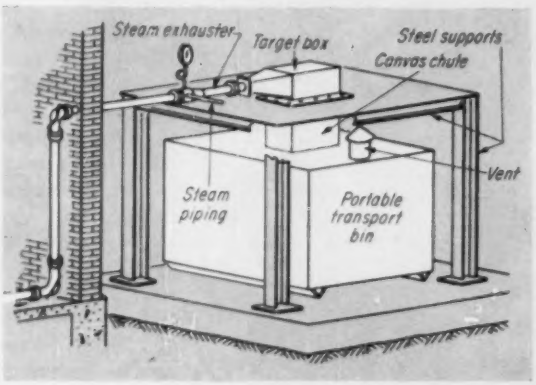
3 • Cable-accessory kit 735 is for hermetic oil sealing in pothead terminations for paper lead cable operating in 23- to 35-kv range. Brush on epoxy resin and wrap Orlon tape over conventional stress cone. Apply pothead filled with oil; leave space for expansion, contraction. No exterior oil reservoir needed.—The Epoxylite Corp

information center for new products and materials

Ash-removal system is designed and priced for small coal-burning plant

4 • Packaged ash-handling system meeting needs of the coal-burning plant with two to four small boilers is first of its kind, maker claims. Up to now ash-handling equipment has been designed mainly for utilities and plants with large steam generators.

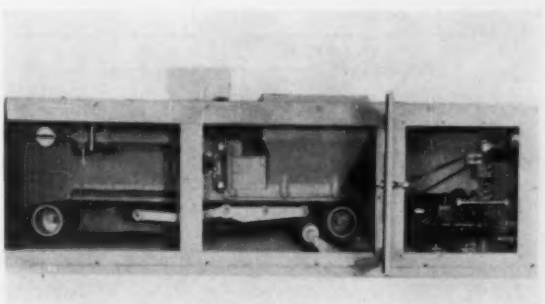
In this system ash is raked from boiler ashpit onto flat anvil plate. Dust shields prevent ash from spilling on boiler floor. Pipeline's intake fittings are opened by a plug and ash is raked into the opening. Vacuum cleaning attachment comes with steam-jet or mechanical exhauster to provide vacuum for the air stream, right. Temporary cinder-block ash-storage bin or 7-ft-sq steel container collects ashes for removal and final dispersal. Cinder-block type has front-end loaders for trucks; steel unit is moved intact to point of final dispersal. Components except pipe are factory assembled, tested and ready for installing.—The Allen-Sherman-Hoff Company



Feeder handles dry chemicals

5 • General-purpose feeder handles chemicals in powder, granule or lump form up to 3¼-in. dia. Maker suggests applications in water- and waste-treatment industries.

Unit has finely balanced weighing mechanism giving accuracy of ± 1% of the set rate over an operating range of 20:1. All electrical and operating controls are integral parts of the unit—separated from feeding mechanism by a dust-tight partition. Entire unit is housed in a dust-tight enclosure.—Infilco, Inc



Desuperheater works with turndown ratios of 50 to 1

6 • Atomizing type steam ejector performs in ranges of 10 to 50 F above saturation temperature with adequate pressure and temperature controls. Atomizing steam pressure must be at least 1½ times superheater steam pressure and 2% of total flow—unit's only limitation, maker says. Feature: straight-through-flow design, manufactured for installing directly in the superheated steam line with welded, flange or nozzle connections.—Schutte and Koerting Co

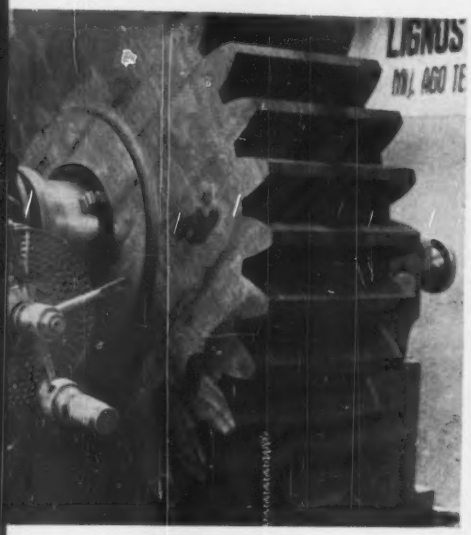
Flame detector for ultraviolet region

7 • Unit senses flame presence and operates a relay to provide alarm signal in the event of flame failure. Responsive to radiations from 2000 to 2500 A, flame detector will operate to 300 F. Since it responds only to flame it's watching and not to adjacent flames or radiation from refractories, monitor is good for individual burners in gas, oil, coal or combination - fuel - fired furnaces. It comes in lightweight aluminum case. —Bailey Meter Co

For more data on these developments, circle key numbers on Reader Service card, p 139

More **equipment news**

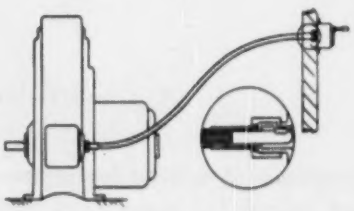
For more data on these developments, circle key numbers on Reader Service card, p 139



LIGNOSTONE GEAR resists oil and abrasion. It looks like wood but is harder than the hardest woods, easy to machine; it features insulating properties

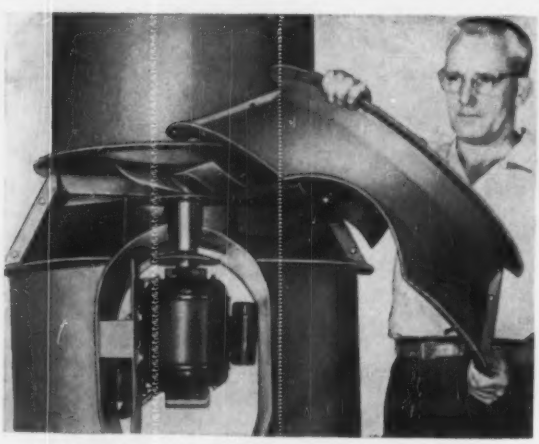
Densified wood is thermo-hardened for strength

8 • Compressed under great heat, this wood is made of beech veneers and solid beech blocks. It's strong and tough as metal but a lightweight in comparison and easier to machine. It's used for bearings, sheaves, connectors, switchgear as well as insulating. For electrical equipment, beech veneers .040 or .078-in. thick before compression are cross bonded with 26% phenolformaldehyde resin and pressed under heat to a density of 1.30 to 1.34 specific gravity. End product is nonporous with good tensile strength and dimensional stability. One nuclear use: neutron shielding.—Lignostone Import Co



Flexible-shaft assemblies come in 180 variations

9 • Standard assembly is offered in four different cable sizes: 0.130, 0.150, 0.187 and 0.250 in. Apply as a standard flexible shaft or standard panel-mounted flexible shaft with mounting nuts as part of the shaft itself. Shafts come with unidirectional cable for motor-driven or high-speed applications and bidirectional cable for hand-operated control.—F W Stewart Corp



Duct fan's removable cone reduces maintenance, downtime

11 • Duct fan, above, is designed with a cone which can be easily removed for savings in both time and $$$. Removal is easy—entire half of cone unbolts—you just take it off. According to maker, this feature is handy for plants using duct fans to exhaust air containing abrasives, chemicals or other materials which cause excessive wear or corrosion on fan blades.—American Machine and Metals, Inc, DeBothezat Fans Div

Grease additive fights h-t lube-oil deterioration, reduces bearing corrosion

10 • Designated UOP-225, additive has no metal or phosphorus, leaves no combustion ash. And it is stable at temperatures above 500 F. According to maker, you can dissolve it in petroleum and synthetic lubricants.

Additive offers corrosion protection for all bearing metals plus titanium, aluminum and magnesium. Inhibitor is compatible with common lube and transmission-oil detergents, also suitable for diesel, electrical-transformer oils. It is ideal for steam-turbine lubricants since it will not dissolve in water.—Universal Oil Products Co

Additives attack residual-fuel-oil, utility-boiler problems

12 • Dearsol 30 is a sludge dispersant and combustion catalyst that helps keep strainers, burner tips, filters, oil lines and oil preheaters from clogging. A stable liquid product that you can dissolve in all residual fuel oils, additive improves combustion and eliminates excessive smoke and heat-wasting soot deposits, says maker.

Dearsol 35, a liquid organic catalyst, helps complete fuel combustion, may be only fuel additive needed when sludge problems are not significant, maker says. It is soluble in residual fuel oils at all concentrations. Both products are used undiluted, one qt per 1000-gal fuel oil.—Dearborn Chemical Company

For more data on these developments, circle key numbers on Reader Service card, p 139

circle 269 on Reader Service card, p 139 ➤

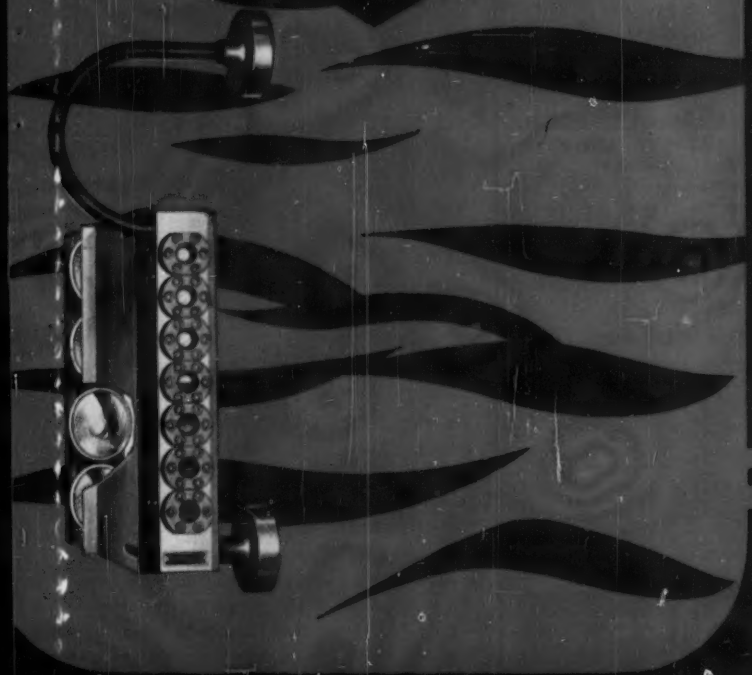
CONDENSATE BY-PASS . . . DIRECT ROUTE TO IMPROVED WATER LEVEL INDICATION

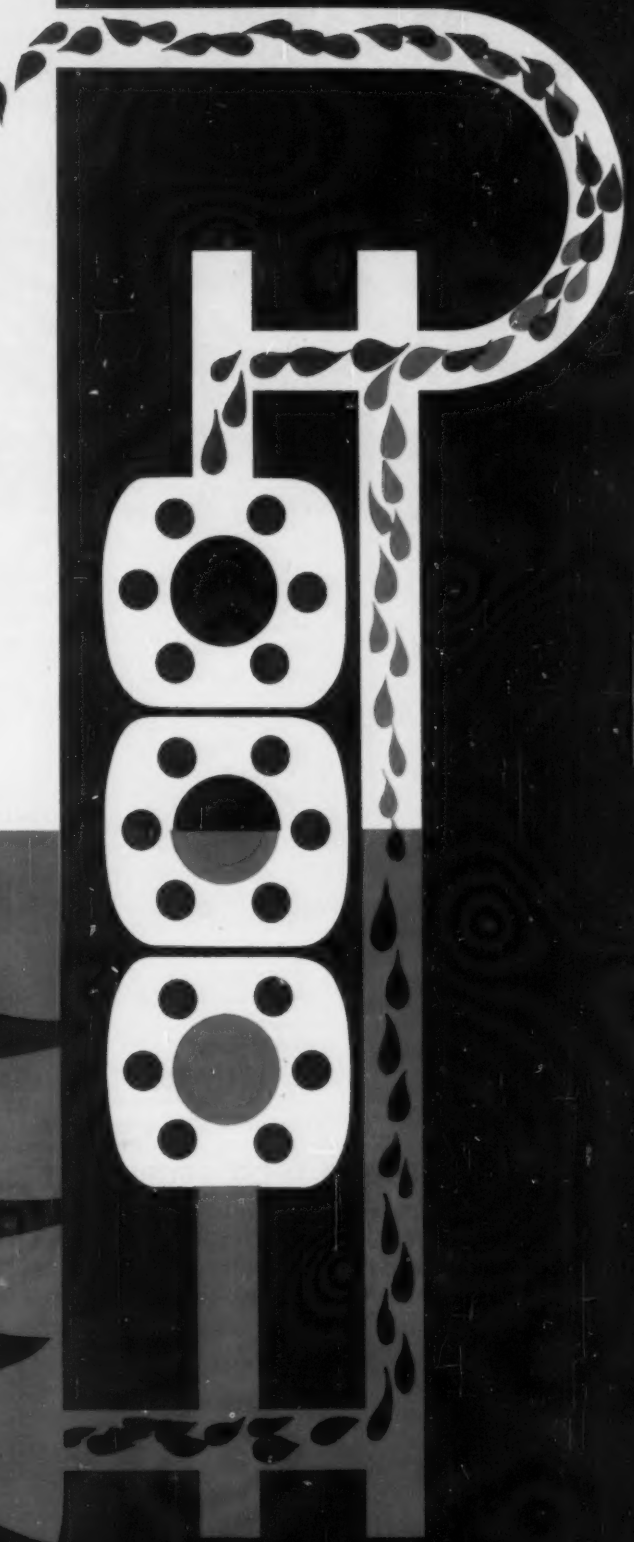
Unmistakable water level readings are assured with Diamond's MP-3000 Multi-Port Bi-Color Gauge, equipped with condensate by-pass. A major reason for such performance is the unique and exclusive by-pass which traps any condensate before it reaches the port channel. The absence of condensate in the port channel assures a distinct bi-color image — red for steam, green for water. Regardless of operating pressure, there's a Diamond Gauge to provide accurate water level readings. Write for complete information or contact your local Diamond representative.

Diamond Power Specialty Corporation, Lancaster, Ohio

Diamond Specialty Limited • Windsor, Ontario

Diamond





67 Problems Solved by Van-Cor PVC Pipe & Fabrications

✓ CHECK THIS LIST

PIPE

Piping Sulphuric Acid
Piping Hydrochloric Acid
Piping Nitric Acid
Piping Battery Acid
Piping Vinegar
Piping Brine
Piping Natural Gas
Piping Ammonium Nitrate
Piping Gasoline
Piping Fluoridation materials water system
Piping Sodium Hypochloride (Bleach)
Piping Pulp Stock Lines
Piping Uranium ore slurry
Piping Sand slurry
Piping Coal slurry
Piping Waste Lab Drains
Piping Cyanide
Piping Plating Solutions
Piping Mercury (tube filling)
Piping Pickles
Piping Polysulfide
Piping Wine
Piping Gin
Piping Whiskey
Piping Sea water
Piping Chicken feed
Piping Demineralized H_2O
Piping Warm glue
Piping Salt water
Piping Crude oil
Piping Drinking water
Piping Irrigation water
Piping Chilled water
Piping Sewage
Electrical Conduit
Fishing Boat Outriggers
Stair Handrails
Vent Stacks
Stand Pipes
Downspouts
Cathodic Protectors
Electrolytic Interruptors
Pneumatic Conveying

FABRICATIONS

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Hydrofluoric Fumes (Scrubber and duct)
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Spray Booths
Roll Coverings
Swimming Pool H_2O Treatment
Chicken Feed Troughs
Gutters
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Electrolyte Diffusers
Agitator
Noise Dampeners
Sinks
Laboratory Table Tops
Photographic Trays
Etching Trays
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Etching Machinery
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Loading Chute Liners
Laboratory Fume Duct
Laboratory Fume Hood
Tanks & Tank Liners

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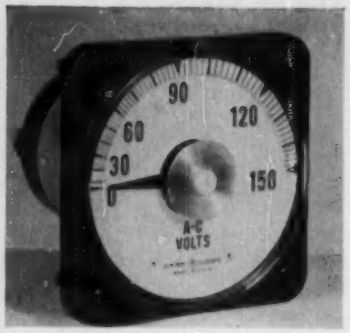
Equipment news

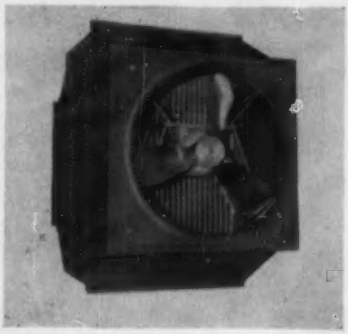
Begins on page 154



Economical switchboard instruments

49 • Ac voltmeters and ammeters feature low cost and accuracy, maker claims. New case design and reduced flange dimension (4½-in. square compared to 6½x7 in.) cuts unit's cost. Scale length is 5.1 in. covering 180 degrees. Ammeter rating is five amp; voltmeter is rated 150, 300, 500 and 600 v. — General Electric Company

Just circle key numbers on the Reader Service card, page 139, to get complete product story



Steam-fired air-intake unit

22 • Air-intake unit replaces air removed by operation of exhaust systems, consists of single cabinet which houses a propeller fan and a steam coil. Four standard units provide 4000- to 36,000-cfm capacity range.

Unit can be installed with or without filters and distribution ducts. If tempered air is not required, leave out the heating coil. For high static applications or when external mount-

For more facts circle 270 on Reader Service card, p 139

Zero leakage nuclear pumps

Four BJ Liner-Motor Pumps Provide Primary Cooling for AEC's SPERT-III Project

High temperature, high pressure and high capacity performance *with zero leakage* are demanded of these four Byron Jackson Liner-Motor Pumps. Employed to handle pressurized water for primary coolant at the Atomic Energy Commission's SPERT-III project near Idaho Falls, the 500 HP pumps are operating at 650° F, 2500 psig, and are rated at 5000 GPM with a total dynamic head of 350 feet.

In building pumps to such critical requirements, BJ calls upon the engineering skills and manufacturing methods that have made Byron Jackson a leader in nuclear pumps for all types of reactors...stationary, or portable. The success of BJ nuclear pump design is proved through the installation or specification of BJ Pumps on practically every major commercial reactor in the United States.

BJ quality *does* cost less in the long run!

Since 1872

BJ

Byron Jackson Pumps, Inc.

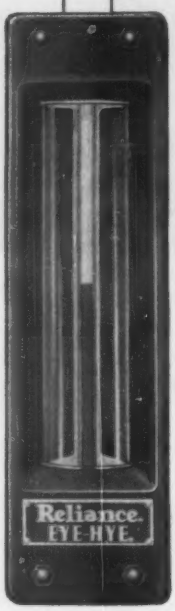
A Subsidiary of Borg-Warner Corporation

P. O. Box 2017-A, Terminal Annex, Los Angeles 54, California

For more facts circle 271 on Reader Service card, p 139

Why a remote reading gage

- Most boiler drums are high — direct gages are far from operating floor.
- Obstructions often make gages hard to see — necessitate special equipment or frequent climbing to inspect.
- Remote gage saves thousands of steps, hours of valuable time. Brings gage reading *down to eye level* at safe distance from boilers.



Why Reliance EYE-HYE

- EYE-HYE assures perfect measurement, dependability and clear reading.
- All-hydrostatic principle — no mechanical parts — no adjustments on location.
- Reads in liquid, like a conventional gage, but easier, faster because of illuminated green indicating fluid.
- Oldest practical remote gage — over 13,000 in use — on land and sea.
- Economical special attachment actuates supplementary alarms, audible or visible, if desired.

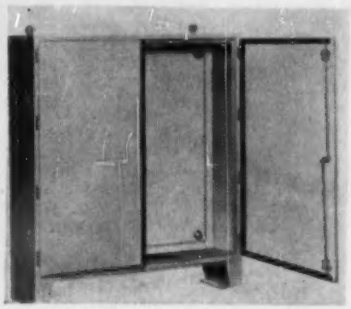
- Available for either wall or panel mounting, new wide-visibility EYE-HYEs are made for any pressure range — up to 3000 psi. Also long window model for unusual liquid level variation — for tanks, heaters, etc.

Write for catalog information on EYE-HYE for *your* boiler pressure.

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio

Reliance BOILER SAFETY DEVICES

ing is necessary, belt-drive duct fans, vane-axial and centrifugal blowers are available. — Hartzell Propeller Fan Co



Extra-heavy panel enclosures

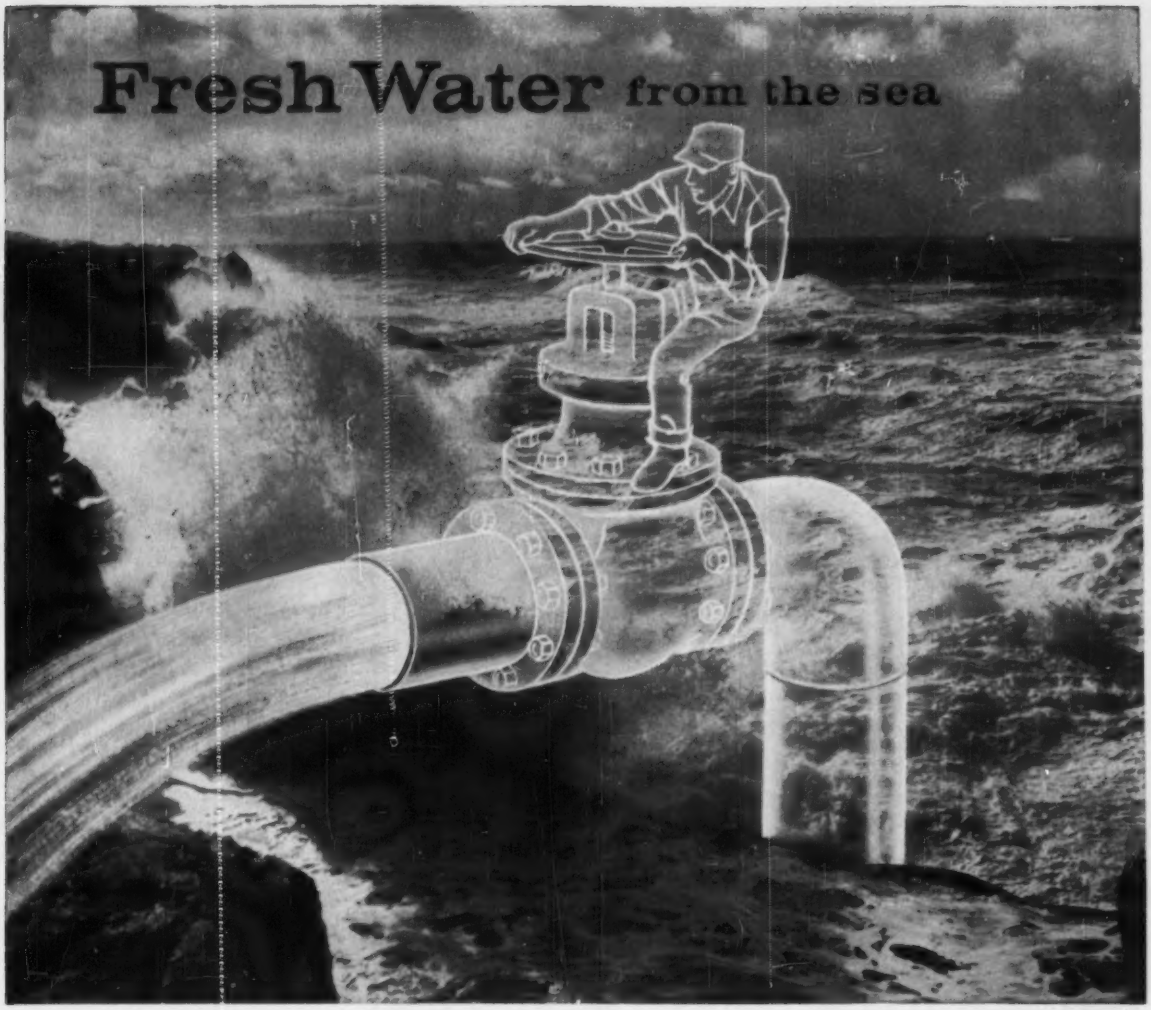
32 • NEMA type 12 panel enclosures are designed to house electrical controls, for use as terminal boxes, to enclose machine-tool wiring and for other applications. Units give complete protection from dirt, oil, water and coolants, according to the manufacturer. They're made of heavy-gage sheet steel and are waterproof.—Keystone Mfg Co

Just circle key numbers on the Reader Service card, page 139, to get complete product story

Continuous silica-concentration analyzer-recorder

80 • Unit prevents dangerous silica concentrations in effluent water of demineralizer systems. Automatic chemical analysis system continuously records silica concentration down to one part per billion. Complete automation of demineralizer plants is possible with on-stream system, says maker.

Analyzer also can automatically signal an alarm, switch the system from one resin bed to another and activate automatic regeneration of the depleted bed. Unit will also continuously record trace quantities of copper, iron, phosphate, chloride and other materials in the steam-water cycle.—Technicon Controls, Inc



Announcing a new company combining 150 years of experience

WEIR CHICAGO BRIDGE designs and builds seawater distillation plants custom engineered to produce the lowest-cost fresh water for any given situation.

This new organization combines the vast experience of two world renowned firms. G. & J. Weir Limited of Scotland has built more seawater distillation plants than all other firms combined. Chicago Bridge & Iron Company are leaders in the fabrication and erection of steel plate structures and process equipment operation on a world wide basis.

The combined resources of both firms are available through Weir Chicago Bridge to produce the most thoroughly proven distillation plant.

If you would like to consider seawater distillation to provide fresh water for domestic use or high purity distilled water for industrial use, please communicate with us at 50 Broad Street, New York 4, New York.

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Babbitt
Adjustable SPROCKET RIM with Chain Guide
Changes that Danger Zone to a SAFETY ZONE

—enables you to ADD PLANT AREA

If re-aligning equipment will yield more working space, better production, lower costs—do it now. Save all space wasted for placing ladders to reach overhead valves. At the same time, convert Danger Zones to Safety Zones. Equip every overhead valve wheel in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
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- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us

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circle 275 on Reader Service card, p 139

HIGH PSI – HIGH TEMP. NO PROBLEM... with these Butterfly Valves!

★ Inlet pressures up to 6000 psi
★ Pressure drops to 1200 psi
★ Temp. range −300°F to +2000°F
★ Sizes 1" to 108" in all ASA ratings
★ Closing speeds fast as 1/3 second
★ Equal percentage flow characteristics for accurate flow control

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BUTTERFLY VALVES

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Direct Inquiries to: CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Penna.

Equipment news

Begins on page 154

Electrostatic-precipitation conversion unit

33 • Unit has silicon rectifier especially for converting electrostatic precipitators now using mechanical rectifiers. Unit uses all existing equipment except rectifier motor, disk, shoes, suppressor elements and pedestal. You tie it with present ac connections and dc switchgear distributing rectified power.

Rectifier has no moving parts—is cheaper than complete new power pack, says maker. Conversion is simple, can be done in 6 to 8 hr.—Buell Engineering Co, Inc

Just circle key numbers on the Reader Service card, page 139, to get complete product story

Start-stop system for power switching

29 • Automatic magnetically controlled start-stop system is specially designed for electric-power-switching operations at unattended facilities. Unit monitors both primary and secondary power sources, performs all necessary switching for continuous power.

Start-stop control automatically starts a diesel or gasoline-generator set when primary power is interrupted. When auxiliary system reaches proper voltage and frequency value, control blocks out primary source and transfers load to auxiliary system.—Lumen, Incorporated

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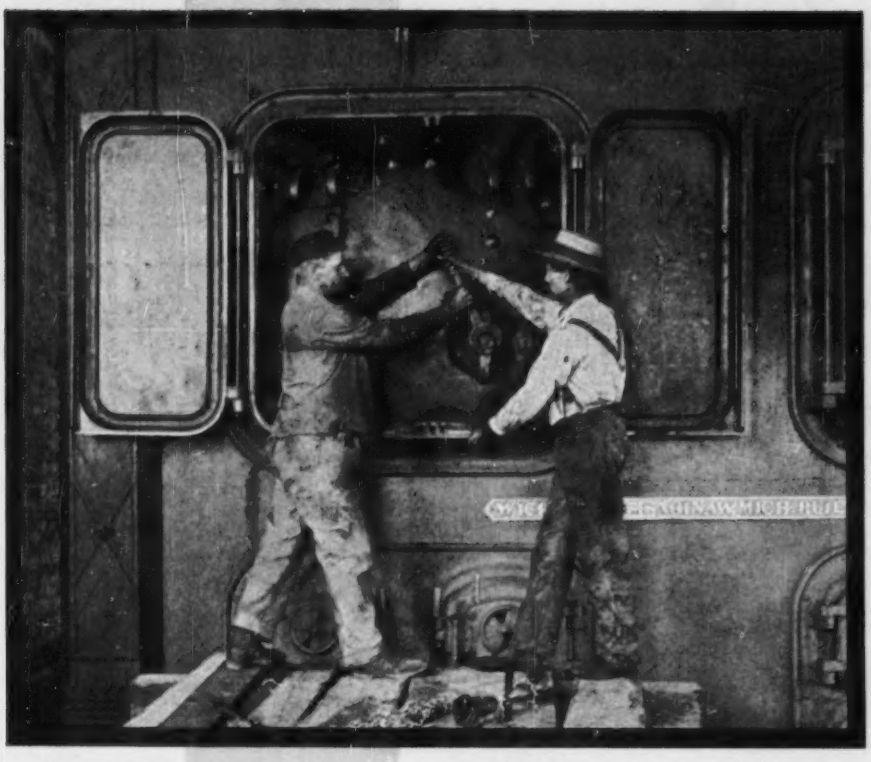
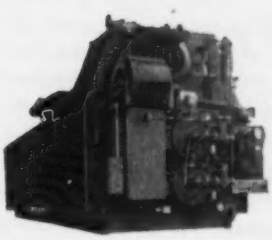


This boiler, built by Wickes Boiler Co. in 1875, operated satisfactorily for the next 31 years.

When buying modern Boiler Equipment it pays to deal with an *EXPERIENCED MANUFACTURER*

There is no substitute for experience. From the first pioneering days in boiler manufacture, years before the boiler pictured above was built, Wickes Boiler Co. has continued to be a world leader in the development of economical, efficient and dependable steam generators. Today, Wickes builds steam generators in sizes to 500,000 lbs. of steam per hour, for high or low steam pressures and temperatures and for all types of fuels and firing methods.

A Wickes steam generator, custom engineered to exact generating requirements, is built to the highest standards of workmanship, backed by over a century of boiler making experience.



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WICKES

173

WICKES BOILER CO. DIVISION OF THE WICKES CORPORATION, SAGINAW 10, MICHIGAN

For more facts circle 277 on Reader Service card, p 139

Nicholson Thermostatic Steam Traps

These traps are only a fraction of your steam equipment cost . . . yet they can do a whale of a job in helping you to get full efficiency from that equipment even with varying pressures. Here's how.

Operating on a true balanced vapor-pressure principle, they discharge air, condensates and other non-condensables promptly, fully and intermittently. What's more, the bellows is located where it belongs . . . at the trap top . . . so that when live steam enters it contacts the bellows the moment the discharging condensate falls below the top of the inlet pipe. Thus, there is a constant water seal to prevent loss of live steam. This, plus the fact that valves and seats are accurately lapped for sure, safe shut off assures you of full thermal efficiency from every pound of steam. Capacity? These traps have it . . . up to six times greater than ordinary traps. Also since there's only one moving part . . . no links, pin, levers . . . your maintenance cost is next to nothing.

Get maximum Thermal efficiency from your equipment. Specify Nicholson Thermostatic Steam Traps. Immediate delivery.

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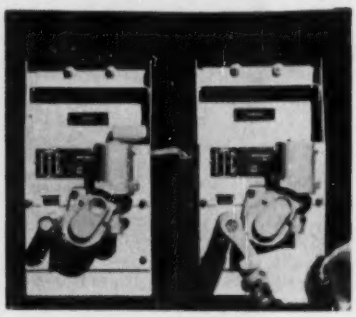
Equipment news

Begins on page 154



Breakers give automatic transfer switching

21 • Unit assures continuous electrical service by using motor operators with circuit breakers, maker says. If normal power is lost, automatic-transfer control system senses loss, starts up a 75-kw diesel-engine generator. When generator voltage reaches proper level, "normal" breaker opens and "emergency" closes to restore power to the building. When normal power comes back on the line, "emergency" breaker opens, "normal" closes after 2-sec time delay. Unit is rated 70 to 800 amp, to 600-v ac and 250-v dc.—I-T-E Circuit Breaker Company

Just circle key numbers on the Reader Service card, page 139, to get complete product story

Shaft-mounted speed reducer

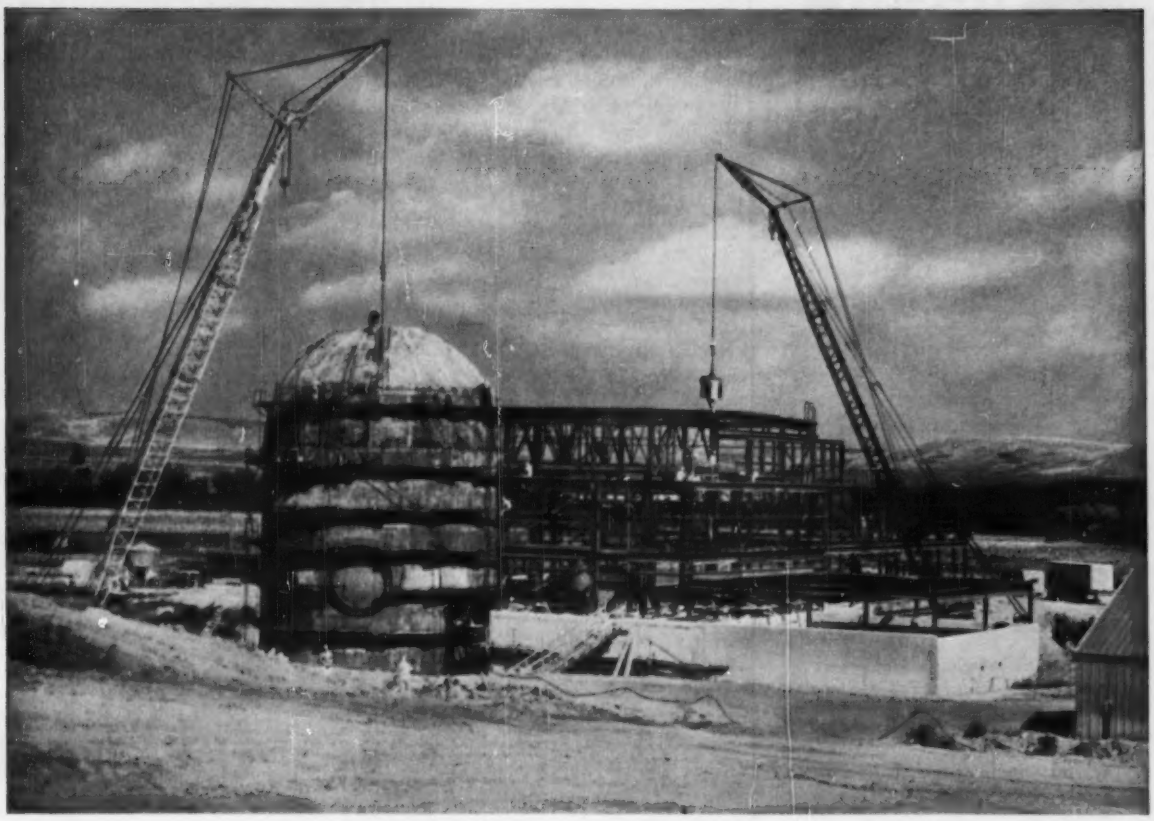
58 • Unit produces 1-, 2- and 3-speed reductions for ¼- to 12-hp range. Less than a foot in diameter and 4¾-in. wide, reducer is a space saver.

All reductions are within the dimensions of the pulley, inside the housing, providing for reductions from 2.52:1 to 76:1.—Hart Reduction Pulley Company

Thermocouple type temperature sensors

51 • Sensors for use up to 4000 F are available cooled and noncooled to measure liquid, solid and gaseous

ALLIS-CHALMERS



A status report:

nuclear superheat...on schedule

"Pathfinder" is the country's first nuclear superheat power station under construction. It is being built by Allis-Chalmers for Northern States Power Company. Cooperating in research and development are nine other midwest utilities* and the Atomic Energy Commission.

The above photo shows the containment, turbine, water treatment and administration buildings. Construction is on schedule.

The integral nuclear superheater will provide steam at 600 psig, 825 F. Other important design characteristics include a high power density — 46 kw per liter — and controlled recirculation — 60,000 gpm.

Only Allis-Chalmers has experience in both direct- and indirect-cycle boiling water reactors, fast breeder, gas-cooled and process-steam reactors and fusion. In addition, A-C has long been a leader in such steam plant equipment as turbine-generators, condensers, pumps, valves and water conditioning systems.

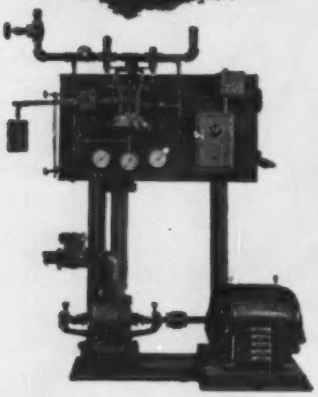
For more information about Allis-Chalmers facilities and capabilities in the nuclear power field, talk to your nearest A-C representative, or write for *Bulletin 43B9541,* **Allis-Chalmers,** Atomic Energy Division, Milwaukee 1, Wisconsin. A-1382

*Central Electric and Gas Co. • Interstate Power Co. • Iowa Power and Light Co. Iowa Southern Utilities Co. • Madison Gas and Electric Co. • Northwestern Public Service Co. • Otter Tail Power Co. • St. Joseph Light and Power Co. • Wisconsin Public Service Corp.

Site of "Pathfinder" plant at Sioux Falls, South Dakota.

Cut Steam Costs

with Stickle's differential drainage and boiler return system



A closed pumping system for returning condensation from heating and processing equipment under pressure directly to boiler at temperatures only 15 to 20 degrees lower than those at operating pressure. For plants using steam pressures between 50 and 250 lbs. Cuts the cost of steam these eight ways:

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Cuts the cost of steam

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Regulating and Reducing Valves
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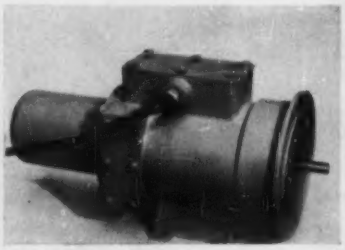
circle 280 on Reader Service card, p 139

Equipment news

Begins on page 154

temperatures. They're made of refractory metals — oxidation-resistant coatings, magnesium and beryllium insulation and iridium, tungsten, and rhenium wires. Applications include measuring temperatures of afterburner exhaust gas, combustion processes and flue gas.—Aero Research Instrument Co, Inc



½-hp motor

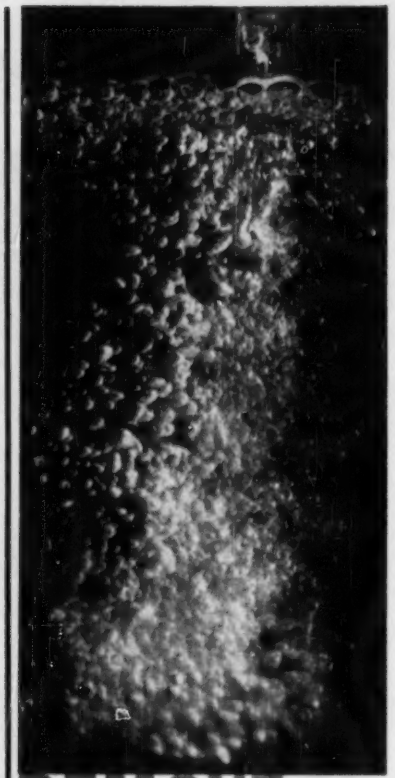
36 • Unit features improved performance against fluctuating loads—under full output conditions 0.5 bhp is available, maker says. Flywheel stores kinetic energy resisting transient changes in torque. It reduces loop gain, is supplied for high resistance to torque changes. With flywheel fitted, acceleration is 1000 rpm per sec. With flywheel removed, machine accelerates at 7000 rpm per sec—speed range is to 7500 rpm forward or reverse.—Servomex Controls Ltd

Just circle key numbers on the Reader Service card, page 139, to get complete product story

Governor maintains steam-turbine drive speeds

18 • Control system maintains speed of steam-turbine line shaft drives to within 1/10% of any set speed throughout 10:1 range, maker claims. Governor does not have to change gears.

Completely static governor, prime sensing element in control system, signals electric speed to electric hydraulic converter. Converter's oil-pressure speed signal operates standard servomotor.—Westinghouse Electric Corp



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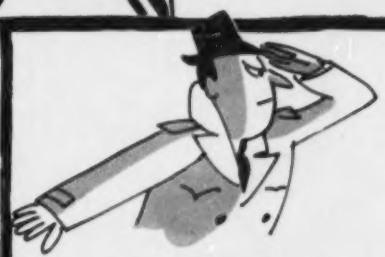
HOW TO SLEUTH OUT THE TRUTH ABOUT EXPANSION JOINTS



1 Case the joint (design, that is)

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2 "Weigh" the evidence

S-R Joints have no bulky castings . . . weigh up to 50% less . . . diameter equivalent to pipe flange. Installation is easier, lighter supports required.

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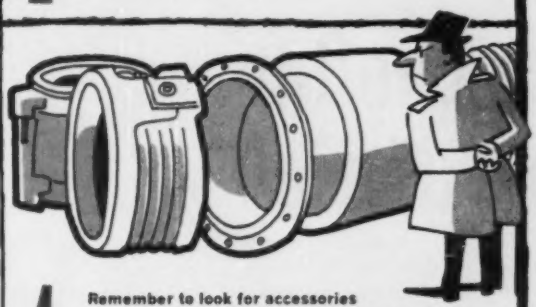

4 Remember to look for accessories

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5 Pull an M.O. on the manufacturer's background

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6 Close the case — buzz Badger

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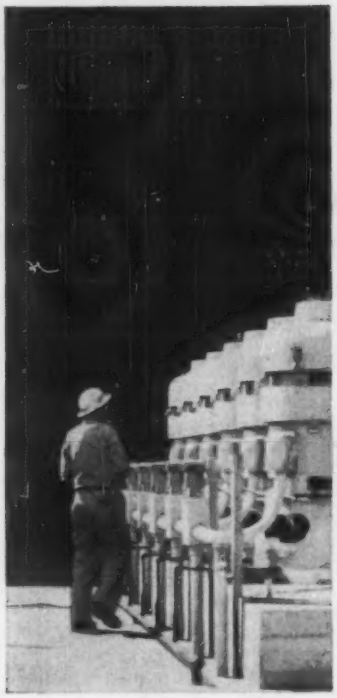

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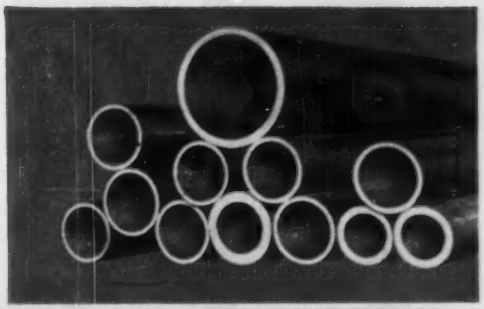

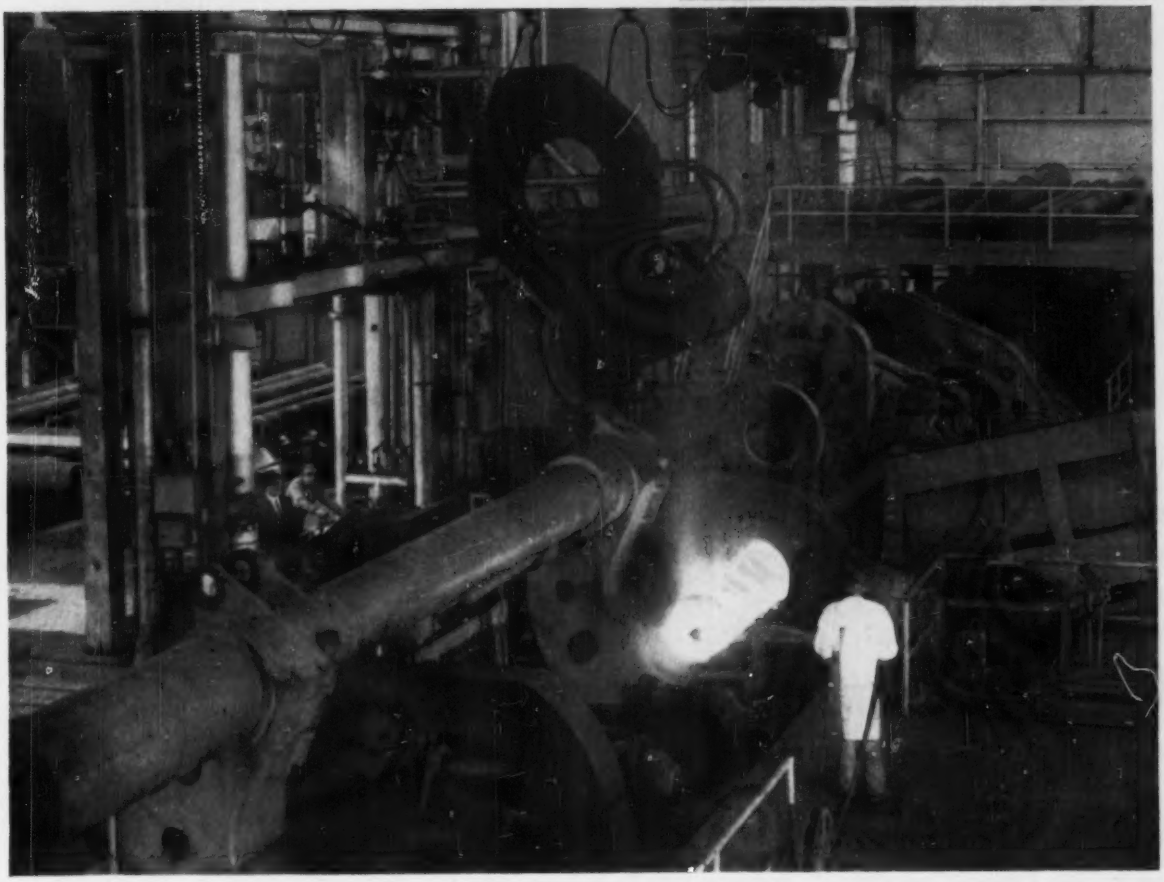

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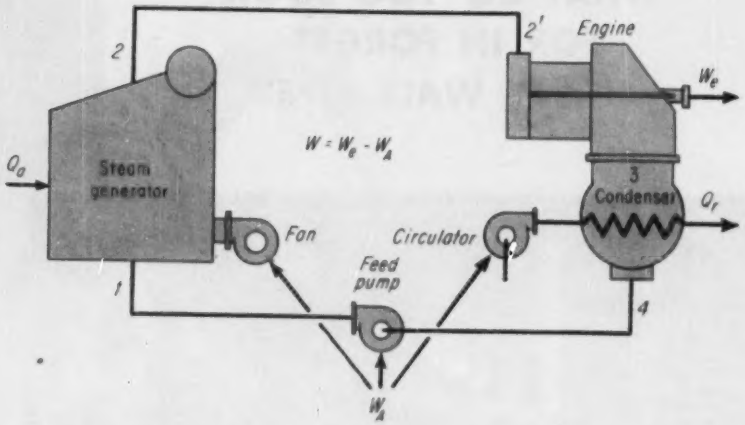
By B G A SKROTZKI, Associate Editor



1 Practical Rankine cycle needs an array of auxiliaries that consume energy and reduce the net work output of the plant. Engine and boiler have losses above ideal

We figure ideal steam power-generating cycles so we can estimate how much practical cycles can be improved. Then we set up efficiency ratios to measure the difference. Here we learn . . .

How to compare actual and ideal cycles

The practical Rankine cycle needs many auxiliaries, each consuming energy. Fig. 1 suggests just a few of the more important. These reduce the net output W and so the thermal efficiency of the cycle. On top of this, none of the cycle machinery works as well as the ideal. So all actual losses are greater than the theoretical, further depressing overall cycle thermal efficiency.

Carnot comparison. While the Rankine cycle is a theoretical ideal, let's not forget it's *not* the best ideal. Carnot cycle still defines the best performance you can expect for given limits of heat added and rejected.

$$\text{Thermal effy} = \frac{T_a - T_r}{T_a} \qquad (1)$$

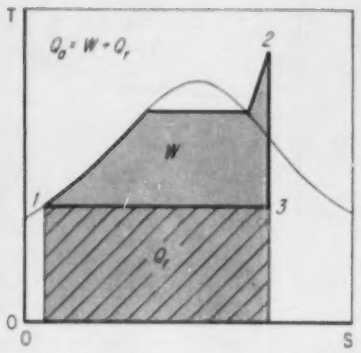
The Rankine ideal falls considerably short of the Carnot. Fig. 2 shows the T-S graph of an ideal Rankine cycle with heat addition at temperatures from T_1 to T_2 and heat rejection of unavailable energy at T_3.

An ideal Carnot cycle would operate with all heat addition at T_2, the highest in the cycle. Fig. 3 shows how a Carnot cycle would compare with the ideal Rankine of Fig. 2. Both have the same T_2 and the same Q_r. The gray areas, of course, measure heat added Q_a. This is much bigger for the Carnot cycle, but note that the additional Q_a for the Carnot all converts to useful work W—dotted line in Fig. 3 shows the comparison of the two W's. This makes the Carnot more efficient thermally.

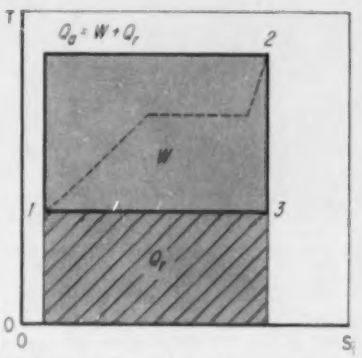
Advanced steam cycles we'll study later all strive to "square off" the T-S graph to approach Carnot thermal efficiency. We might ask again why an actual Carnot engine was not developed because of its superior theoretical performance. Most attempts in this direction showed that the engine would need an extraordinarily long stroke to achieve performance. Practical factors so far have made it uneconomical to develop—but attempts under way might just be successful, eventually.

Engine efficiency. Efficiency of the Rankine cycle depends largely on the performance of the engine. Engine takes in steam with enthalpy H_2, converts some of the energy to work output W_e, rejects the remainder to the condenser as enthalpy H_3 of the steam.

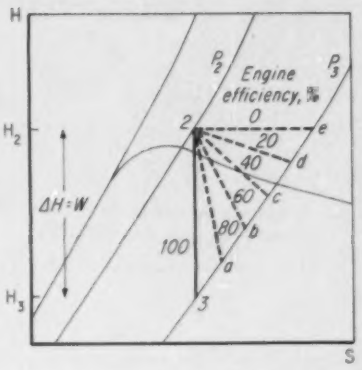
Mollier chart, Fig. 4, shows that ideally the steam would expand at



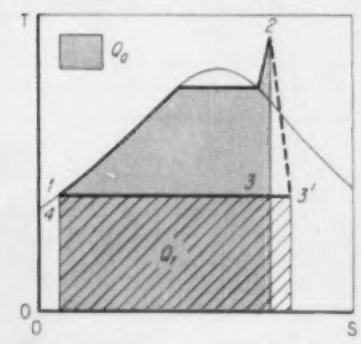
2 Ideal Rankine cycle has net W output that equals the difference of Q_a and Q_r



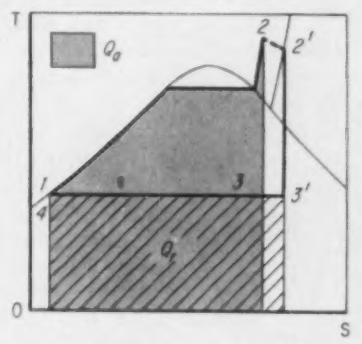
3 Ideal Carnot cycle with same T_2 and Q_r of Rankine proves more efficient



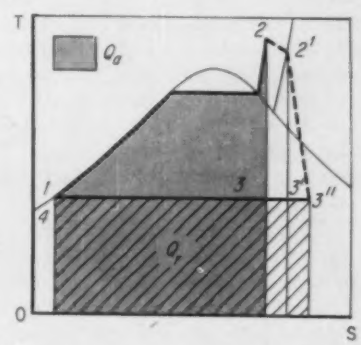
4 Mollier diagram shows effect of engine efficiency on exhaust enthalpy



5 Irreversible expansion of steam in Rankine engine increases the heat Q_r



6 Pressure drop of steam from boiler to engine raises the unavailable heat Q_r



7 Expansion irreversibility and pressure drop make Q_r grow cumulatively

constant entropy S from state *2* to state *3*. Then work ouput would be:

$$W_e = H_2 - H_3 \text{ Btu per lb} \qquad (2)$$

But because of irreversibilities in the engine, all of this theoretical conversion is not realized and some internal energy remains in the steam exhausting from the engine. Actual H_3 might be H_a or H_b, H_c, etc, all higher than H_3.

Actual performance depends on many practical factors of design and loading. To know how close a machine runs to ideal we use the engine efficiency:

$$e_e = \frac{H_2 - H_3'}{H_2 - H_3} \qquad (3)$$

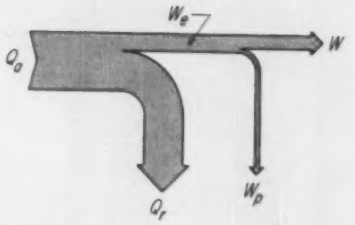
where H_3 is ideal exhaust enthalpy of the steam and H_3' actual exhaust enthalpy. Fig. 4 shows how engine efficiency varies the expansion line of the steam on the Mollier chart. Note at zero engine efficiency that $H_2 = H_e$. This is a throttling process where all the energy remains in the steam while it flows to a lower pressure.

Actual Rankine efficiency. Now let's study what engine inefficiency does to a cycle's performance. Fig. 5 shows the T-S graph for an ideal cycle excepting the engine, which has an irreversible expansion (at increasing entropy) from *2* to *3'*. The ideal expansion would end at state *3*.

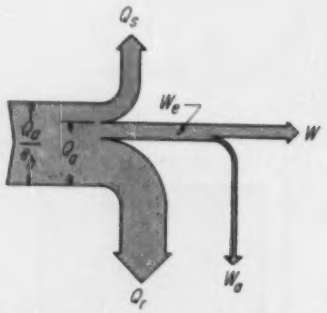
Here we assume that heat is rejected reversibly at constant pressure in the condenser from state *3'* to state *4*. Area underneath measures the heat rejected Q_r. Gray area under *1-2* measures the heat added to the cycle Q_a. Difference of the two areas measures net work output W. But since the two areas do not coincide on three sides, there is no net definable area as in the ideal cycle that we can label W. The actual W is less than the upper gray area by the hatched area under *3-3'*.

As engine efficiency drops, the hatched area Q_r grows and there is less and less net W produced. For zero engine efficiency, or pure throttling, $H_2 = H_3'$ and Q_r would be equal to the gray area and, of course, $W = 0$. This drops cycle thermal efficiency to zero.

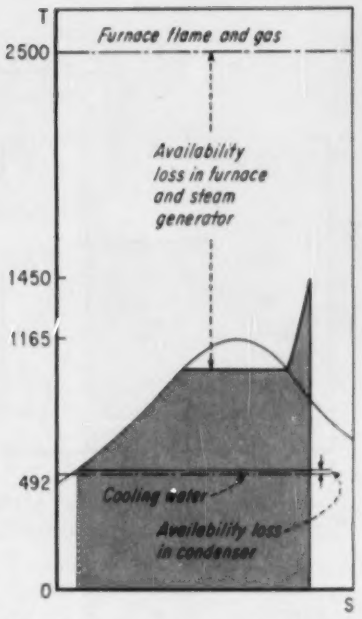
Steam - pressure drop. When steam flows from steam generator to engine inlet, it must overcome the friction and so drops in pressure. Pressure drop causes a loss in cycle thermal efficiency. In Fig. 6 we have



8 Ideal energy-flow diagram shows net W output left after required cycle uses



9 Actual energy flow shows losses up the stack and greater inherent plant loss



10 High temperature drop in bolier furnace offers big cycle-efficiency gain

steam leaving the steam generator at state 2. It drops in pressure to state 2′. Since this is a throttling process (usually with no heat loss) $H_2' = H_2$, there is a slight drop in temperature too. If the steam expanded in an ideal engine it would exhaust with enthalpy H_3'. This is larger than the ideal enthalpy H_3 when steam expands from the steam generator outlet at state 2. Q_r increases and the pressure drop lowers thermal efficiency of the cycle.

Fig. 7 shows the combination of pressure drop and irreversible expansion in the engine. Each acts independently on cycle efficiency—the effects of both add add together, raising Q_r and correspondingly subtracting from net output W. These graphs show the need for careful design to achieve acceptable thermal efficiency.

Actual efficiency. For design needs, the theoretical efficiency is first computed and then efficiency factors applied to estimate actual performance. As we learned in the last part, theoretical thermal efficiency of the Rankine cycle can be figured as:

$$e = \frac{W_e - W_p}{Q_s} = \frac{Q_a - Q_r}{Q_a} = 1 - \frac{Q_r}{Q_a}$$

$$= 1 - \frac{H_3 - H_4}{H_2 - H_1} \qquad (4)$$

In equation 3 we have the engine efficiency e_e. But if we have a substantial pressure drop as in Fig. 7, the equation would have to be used with the understanding that while $H_2' = H_2$, the ideal expansion ends at H_3' as in Fig. 7 and not at H_3.

As Fig. 1 shows, there is additional, auxiliary energy consumption that must be accounted for to arrive at overall cycle thermal efficiency. Also, the steam generator does not get all the energy it releases by chemical combustion into the working fluid. Much of the energy loss disappears up the stack to atmosphere. The ratio of energy transmitted to the working fluid to chemical energy in the fuel is boiler or steam-generator efficiency:

$$e_b = \frac{H_2 - H_1}{F \times HHV} = \frac{Q_a}{F \times HHV} \qquad (5)$$

where

e_b = boiler efficiency, decimal
H_2 = enthalpy of steam leaving boiler, Btu per lb
H_1 = enthalpy of feedwater entering boiler, Btu per lb
F = lb fuel burned per lb steam evaporated
HHV = higher heating value of fuel, Btu per lb fuel

Transposing equations 5 and recognizing that the fuel energy input per lb of working fluid is the overall cycle input, we get, in Btu per lb steam:

$$\text{Station input} = Q_a/e_b \qquad (6)$$

Then if we let W_a represent all the auxiliary energy consumption of the plant cycle we can figure overall actual thermal efficiency for a plant as:

$$e' = \frac{e_e W_e - W_a}{Q_a/e_b}$$

$$= \frac{e_e(H_2' - H_3') - W_a}{(H_2 - H_1)/e_b} \qquad (7)$$

To convert the efficiency from a decimal to percent, multiply by 100.

We can compare energy flow for ideal and practical cycles as in Fig. 8 and 9. In Fig. 8 the ideal input Q_a loses its major portion to unavailable energy Q_r and a small part W_p goes to run the feed pump. This leaves W, net output of the cycle.

Fig. 9 diagrams flow for a practical cycle, where plant input Q_a/e_b is diminished by the boiler losses (mostly stack loss) Q_s to leave Q_a, energy entering the steam. In turn Q_a is disbursed to unavailable energy Q_r and auxiliary work W_a leaving net output W. In the actual cycle Q_r and W_a are larger than in the ideal by the amount caused by irreversibilities of actual equipment.

Availability loss. Since we release our input energy in the form of high-temperature fire the Rankine cycle has more-serious basic losses than we have studied so far. True temperature of energy addition is at fire temperature in the furnace and may range from 2000 F upward. But metal limitations in strength and economics keep most practical steam temperatures to about 1050 F; 1200 F is considered highly experimental.

Fig. 10 suggests the great loss we take in availability when temperature drops from fire to working fluid. At the low end of the cycle we do pretty well — temperature difference of about 10 F to transfer Q_r from steam to cooling water cannot be much improved.

Next month we start studying advanced steam power cycles.

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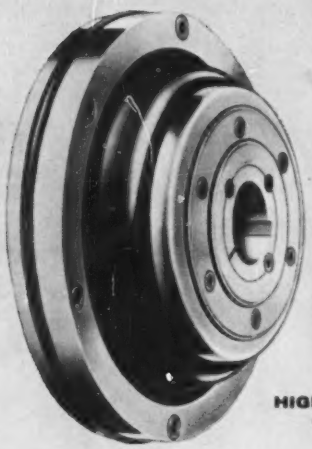

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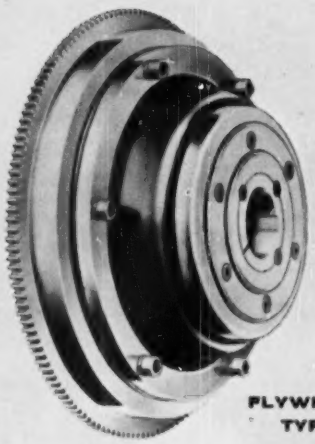

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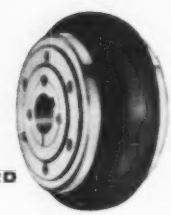

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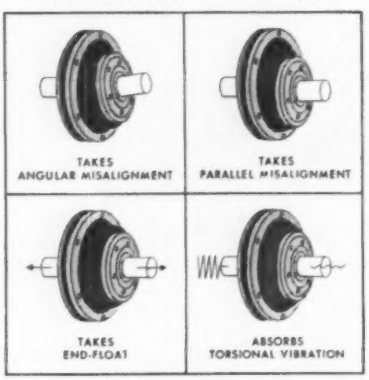

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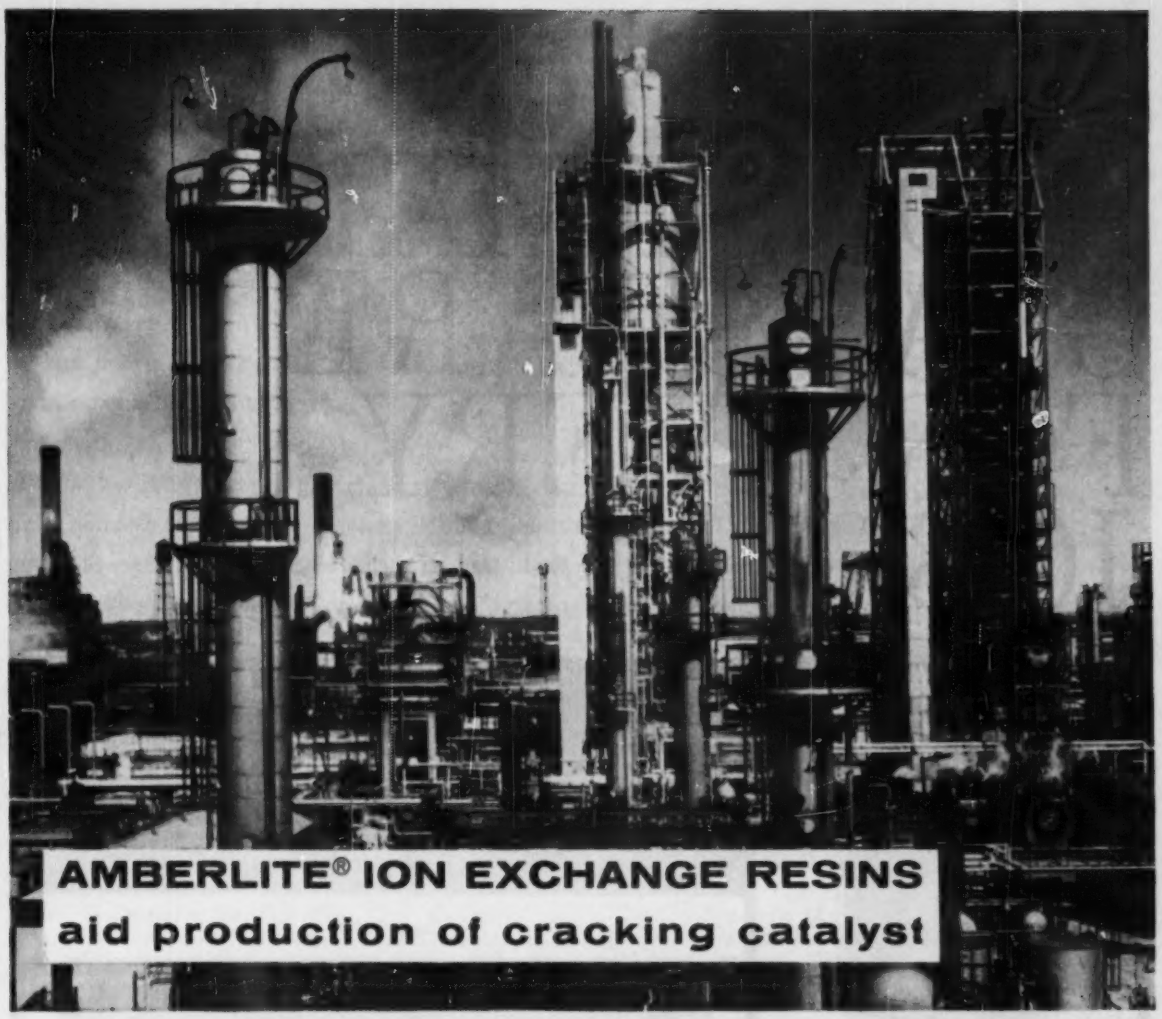

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The Mobil Oil Company Refinery at Paulsboro, N.J., is a volume producer of catalysts for its Thermofor Catalytic Cracking process. To provide water for catalyst and desiccant manufacturing, Mobil runs 1,492,000 gallons of Delaware River water daily through filters and then a two-bed deionizing system. The treated water is used to prepare chemical solutions, and to wash catalyst beads in one of the final processing steps. Water purity is important, since contaminants could affect the chemical behavior of the catalyst. Mobil's anion exchange units use AMBERLITE IR-45. In over 5 years of service, each cubic foot of this anion exchange resin has treated more than 1,500,000 cubic feet of water. Mobil Oil was one of the pioneers in using ammonia to regenerate AMBERLITE IR-45 in a commercial installation. Switching from caustic soda to ammonia regeneration reduced rinse time as much as 63 percent and cut operational costs substantially.

Other fields in which Rohm & Haas ion exchange resins give efficient service include chemical processing, recovery of metals from ores and waste streams, drug manufacturing, food processing and deionization of boiler water for power generation. Write for a copy of a recently published paper on ammonia regeneration of a weakly-basic anion resin. Also ask for our 24-page booklet, *If You Use Water.*

Anion exchange units at Paulsboro Refinery, Mobil Oil Co.

Chemicals for Industry

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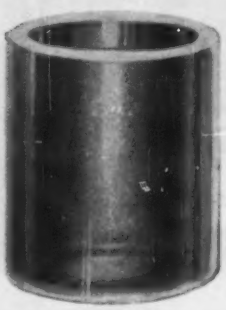
Lubrication inspection



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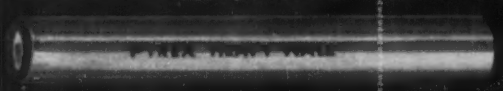

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Visible discharge

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CORNING GLASS WORKS

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Facts you should have on file under "stokers"...and "savings"

(File this page, send coupon now)

Whether your company will talk new stoker next month or three years from now, your review of stoker performance will not be complete without the facts on AE Vibra-Grate Stokers and the outstanding savings assured with the exclusive Vibra-Grate design.

The AE Vibra-Grate Stoker is the only stoker which combines the maintenance-savings features of water cooling and the high-efficiency features of a vibrating grate and controlled zone undergrate air.

Operating reports from some of the country's most cost-conscious companies now using Vibra-Grate Stokers are nothing short of phenomenal.

For example: A 40,000 lb boiler fired by a Vibra-Grate Stoker at S. C. Johnson & Son (makers of Johnson Wax Products) has never had an unscheduled shutdown since the stoker was installed in October 1954. Coal savings have averaged 919 tons per year. There has been no trouble with clinkers or coking coals. Total repair costs for the first five years, when 34,962 tons of coal were consumed, were only $188. A hair over ½ cent per ton of coal!

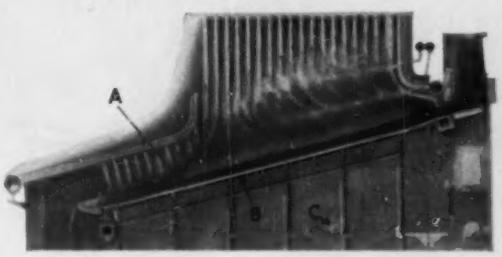
For example: At Spaulding Fibre Company, two Vibra-Grate Stokers have saved 2000 tons of coal in two years, compared with other stokers in the same plant. Average evaporation on one unit is 10.6 lb of steam, 10.8 on the other, using coals having an average Btu value of 13,173. The company writes, "... efficiency and operating economies far in excess of the manufacturer's guarantee and our highest expectations".

For example: Savings of $300 a day are reported by a major textile manufacturer. In this instance oil fired boilers were replaced by a 70,000 lb/hr Vibra-Grate Stoker. The unit is operating at 80.7% efficiency, even though the boiler has no heat recovery equipment.

For example: An old 40,000 lb/hr boiler was restokered with a Vibra-Grate for Edgewood Division, Pilgrim State Hospital, Brentwood, Long Island. Savings are averaging 8 tons of coal per day.

Highest efficiencies anywhere

Because the AE Vibra-Grate Stoker design is completely different you get a range and combination of advantages not possible with any other stoker.



The vibrating grate (A) insures compact distribution of fuel, and elimination of holes and light spots. Thus, the stoker can handle low or high volatile bituminous coal, as well as lignite and semi-anthracites—wet or dry.

Water-cooled grate (B) permits use of gas or oil fuels, singly or in combination with coal. Clinkering and coking are minimized, grate maintenance is virtually nil.

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The complete Vibra-Grate story is covered in our new catalog S-546-A. Send for your free copy now, so all the Vibra-Grate facts will be available when you need them.

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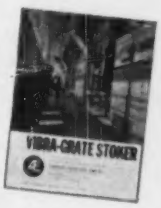

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☐ Please send new catalog on Vibra-Grate Stokers.

☐ We would like to discuss our stoker needs. Please have a representative call. We understand there will be no obligation.

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"BILGEWATER on blueprints," roared Marmaduke Surfaceblow, stepping into his khaki boiler suit and zipping it up quickly

Marmy cools some hotheads

"Mr Wentz is on the phone again, Mr Bailey," chirped Gloria Simpson, sticking her pretty blonde head into her boss's office. "He sounds as if he's still simmering."

"OK, I'll talk to the cranky old hash slinger," answered the field engineer, reaching over a stack of blueprints for his phone.

"Lissen, Herr Bailey," a foreign accent sputtered over the wire. "Vat you are drying to do—serve up mine customers mit sauerkraut yet? Iss 92 degrees outside but maybe a hundred in diss air-conditioned—humph—dining room. You waiting for winter to make mit dat cool air yet?"

Fred Bailey was on the griddle and he knew it. The shiny new air-terminal building had been completed and opened several weeks before. It was the latest thing in terminals and the pride of the city. Efficiency, order and comfort had replaced delay, confusion and the shabbiness of the old terminal. Long ticket counters, automatic baggage-handling conveyors, telescopic loading ramps, a huge comfortable waiting room, stores, lunch counters and an ornate dining room and cocktail bar had a relaxed and even a posh atmosphere.

There were seven 50-ton capacity air-handling units scattered about inside acoustical hung ceilings. Each was supplied with chilled water from a central system. Six of the units were working perfectly but the one in the main dining room just wouldn't cool. And that was one of the most-popular spots in the proud new terminal these hot summer days. From the day it opened, the dining room was constantly jammed with customers — and they always left blowing off steam, thus adding to the cooling load and compounding the problem for all concerned.

"I'll send a man over on the double, Mr Wentz," promised Fred Bailey, nervously lighting a cigarette as he hung up.

"Gloria," he called to his secretary, "will you get Tom Barber in here as soon as he shows up?"

Ten minutes later tall, lanky Tom Barber walked into the field-engineer's office. Tom was a good-natured, clean-cut, likeable young man. He had a degree from a leading engineering school and had tried to get into the design section of the city's engineering department. But Fred Bailey needed a man just then to head up maintenance. He thought a few years of experience coming face-to-face with practical problems would do Tom plenty of good. His reasoning was right, but not for Tom. What

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MAIL EARLY!!

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Marmaduke

Begins on page 178

Bailey had not thought of was that some of our brightest engineers simply aren't cut out for maintenance, just as some of the most ingenious maintenance men can never get their teeth into design work. Tom was what the practical boys referred sarcastically to as a "paper jack"—although he was a very good paper jack. But he wouldn't make a trouble shooter in a coon's age.

"Wentz called again," explained Bailey without looking up from a pile of specifications. "You've been on that terminal job now for two weeks. I don't blame him for blowing his fuse. After all, he's shelling out plenty of clams for a cooled space and he hasn't had it."

"That job's a real bastard—driving me nuts, too," confided Barber, easing his immaculately dressed self into a chair. "Can't understand it. The other six units are perfect. I've checked that haywire system in the dining room 17-dozen times. I've gone over the drawings and even checked them against the others. But I still can't find the bugs."

"How about the manufacturer?" asked Bailey impatiently, "can't he straighten it out?"

"Their man checked the controls for that unit again last Monday, said they were hooked up according to Hoyle," replied Barber hopelessly. Then he added as an afterthought, "And yesterday I had the piping contractor look it over. He claimed the system was installed according to the plans and he couldn't waste more time on that job."

While Bailey was staring over the head of his young maintenance assistant, wondering about the next move, a short beefy man barged into the office. Brushing aside Bailey's weak "Good morning, boss," he started to rave.

"You're sure cooking with high-test gas, Bailey," he blurted. "I just stopped off at the airport dining room for breakfast and I got a Turkish bath. That place is hot enough for a crematory. I don't see how Wentz and his employees stand it—especially the kitchen mechanics." But before Bailey could answer, his corpulant boss added, "don't forget he wore a battered grey bowler perched on one side of his unruly hair. A

POWELL PRESSURE SEAL VALVES

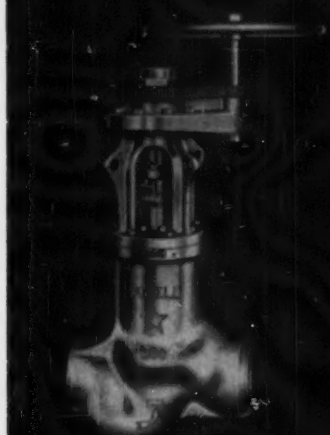

Fig. 19084—Steel Pressure Seal Non-Return Globe Valve for 900 pounds W.P. Spur Gear operated. Can also be furnished with bevel gears if required.

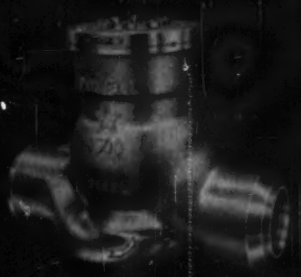

Fig. 11365—Steel Pressure Seal Horizontal Lift Check Valve for 1500 pounds W.P. Powell streamline design assures maximum flow through with minimum pressure drop and turbulence.

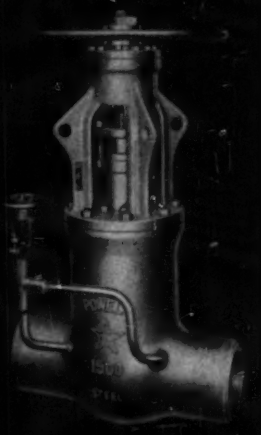

Fig. 1313—Steel Pressure Seal Gate Valve, with By-pass: for 1500 pounds W.P. By-pass valve is Powell Integral Bonnet Angle Valve, Fig. 1333A, for 1500 pounds pressure.

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Keeping modern industry's constantly mounting temperatures and pressures in check demands rugged, dependable controls. Powell Pressure Seal Valves have proved equal to this task in more than 10,000 installations the world over. Precision-built, precision-tested, leak-proof, with many exclusive design and construction features—Powell Pressure Seal Valves are available in gate, globe, angle and check patterns for 600 to 2500 W.P., and special working pressures upon request. Many are in distributor stock or factory stock for quick delivery.

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state-legislature banquet slated for the dining room next Thursday evening. If you don't desuperheat that fancy beanery by then, the mayor'll hand me my head on a silver platter for sure."

Ten minutes later Barber left the office with a batch of blueprints and instruction pamphlets under his arm. A half-hour later he arrived at the airport and entered the dining room with one of the terminal's maintenance mechanics at his heels. As the mechanic checked everything, Barber comfortably directed the operations from a corner table, leaning over his blueprints as he chain-smoked cigarettes and gulped down cups of black coffee. By the end of the day the swanky dining room was still sizzling hot, the customers were still wilted and squawking and Mr Wentz was still threatening to sue the Municipal Terminal Association for leasing him a furnace instead of an air-cooled space.

By Wednesday morning, just one day before the big party, pandemonium had broken loose around the new terminal. The building staff had been alerted to put their best foot forward for the legislature's inspection and to have things shipshape. Plan was for the inspection party to make a grand tour of the building, then end with a banquet in the main dining room that evening. There the mayor would represent the city and the governor would say a few kind words in behalf of the state.

At 11 am on that Wednesday, the thermometer clung to 94 deg outside. Mr Bailey, the Municipal Terminal Association's superintendent of buildings, the air-conditioning contractor, the machinery manufacturer's guarantee man and Tom Barber all descended upon the dining room like a horde of sailors let loose on a tropical island after a long voyage. Mr Wentz, the restaurateur, was there too—and everyone knew it, including the slightly wilted customers.

About the time Wentz started waving his fat arms and shouting loud enough to be heard outside on the runways, a husky 6-ft 4-in. character brusquely entered the dining room. His

For more facts circle 293 on Reader Service card, p 139

circle 294 on Reader Service card, p 139 ▶

Cost-cutting step taken 26 years ago still paying off at Hamm Brewery —they chose NONPAREIL Turbine Oil

Situation: In 1934 the Theo. Hamm Brewing Company installed two 1,000 kw. turbines. The brewing firm wanted to be sure there would be no down-time due to failure of the lubricant. Neither did the company want to spend time checking the oil's performance or adding new oil to sweeten the old.

What was done: Brewery management followed the advice of the Standard Oil lubrication specialist. They installed NONPAREIL Turbine Oil, the only oil, then as now, that carries with each fill a life-of-turbine guarantee.

What has happened: In 26 years since the turbines were put in service there has never been any down-time due to lubrication problems. In 1947 a 2500 kw. turbine was added to the system and another 3000 kw. unit was put in service in 1953. These, too, have used NONPAREIL Turbine Oil with the same results.

What you can do: Get the full story on NONPAREIL Turbine Oil from the Standard Oil office near you in any of the 15 Midwest and Rocky Mountain states. Or write **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

Quick facts about **NONPAREIL Turbine Oil**

- Will not permit formation of harmful acids
- Will not permit formation of sludge or oil varnish
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Hamm Brewing Co. assistant chief engineer Steve Wappel and Standard's Dick Anderson discuss recent oil analysis. Dick Anderson knows his way about an industrial power plant. He's been providing customers with technical service on lubrication for five years. Dick has an engineering degree from the University of Minnesota and has completed the Standard Oil Sales Engineering School.

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mean
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DOLLARS?
DANGER?

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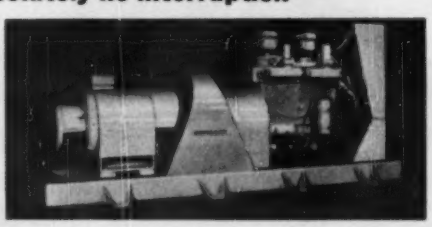

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Marmaduke

Begins on page 178

flashy checkered vest screamed for attention from beneath his shiny blue-serge jacket. Barging over to a table he dropped his handbag on the floor as he anchored himself firmly to a modernistic, streamlined chair.

"Stand by to abandon ship!" he suddenly thundered, jumping up. "What is this, the Black Hole of Calcutta?" He yanked a small face towel marked Hotel Hilton out of his hip pocket and started wiping the perspiration from his leathery neck and face as he listened to Wentz's broadcasting near his table.

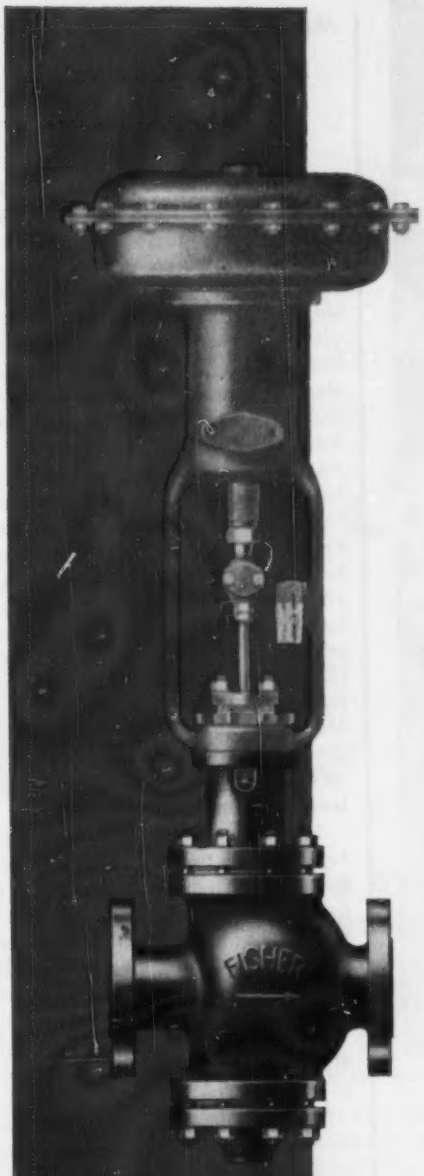
"Ach yah, while you shmardt guys fiddle mit dat air-conditioning system da beoples come in and don't even zit down. Den dey schoodt out again. I haben't seen enough gelt to pay mine rendt or mine help. Und even Franze, mine Choiman chef, quitted me. . . ."

"My name's Marmaduke Surfaceblow," rasped the muscular gent as he navigated over to the unhappy group after listening a few minutes. "I'm a human bloodhound when it comes to sniffing out air-conditioning troubles. While sailing to every corner of the globe, from Chattanooga to Baghdad, as a marine engineer, I've resurrected all kinds of beatup machinery that was given up for dead. I'll be happy to make a stab at turning this Death Valley into a windkissed South Seas paradise. But it'll cost you 300 iron men, and cash on the hatch covers at that."

For a second everyone was too dumfounded to utter a sound. Then the super spoke up. "That's a lot of cabbage to shell out for a little cool air."

Marmaduke yanked a huge gold watch out of his vest pocket by its heavy chain, snapped open the lid and bellowed. "My plane shoves off in exactly 46 minutes. I never quibble. If I don't deliver the freight you'll still have your money and your Sahara desert. So what is it, full-speed ahead or stop?" He snapped shut his watch.

"That's a deal," blurted the super quickly, as the bright light of logic suddenly penetrated his skull. "You've got us going over Niagara without a paddle so let's see you get that South Sea breeze blowing." continued



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	Cast Iron ASTM A126-B	Nodular Iron ASTM A395	Cast Steel ASTM A216-WCB
Tensile Strength, PSI	31,000 Min.	60,000 Min.	70,000 Min.
Yield Strength, PSI		45,000* Min.	36,000 Min.
Elongation, % in 2" Gage Length	NIL	15	22
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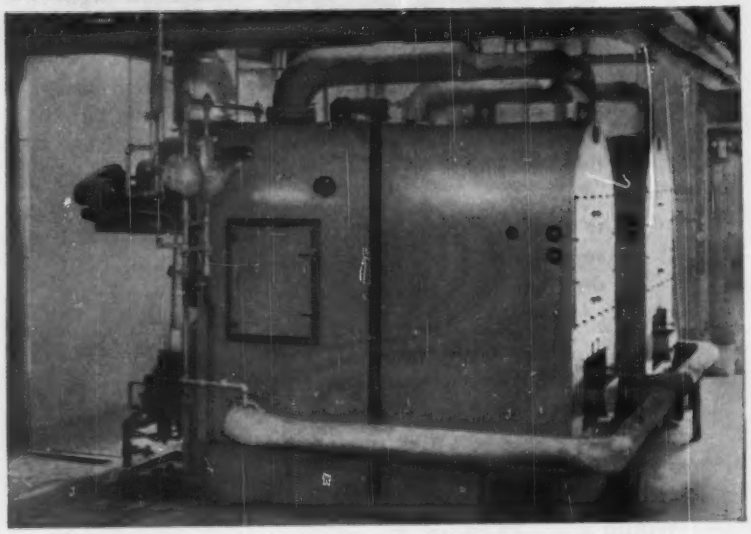

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Marmaduke

Begins on page 178

"Here are the blueprints," piped up Tom Barber, helpfully extending a roll of plans to the stranger.

"BILGEWATER on prints!" roared Marmy in his foghorn voice. "Aboard ship we shoot trouble by lifting floor plates and crawling through bilges to trace out our lines. I got my trouble-shooting gear right here in my handbag." With that he plopped his leather bag on the table, unrolled a worn khaki boiler suit and stepped hastily into it before any comment could be made. He reached into his bag, pulled out a long, shiny flashlight and zipped up. "Now, matey, chart the way to that hung ceiling," he barked. The young maintenance engineer seemed frozen for a second, then as automatically as a robot he made a beeline for the kitchen. Marmy followed. There he climbed the wall ladder shown him and quickly disappeared through an opening leading into the hung ceiling.

Ten minutes later Marmy hot-footed out of the sweltering kitchen, puffing furiously on a black cigar butt and exhaling shafts of dark, acrid smoke from his nostrils as he dripped perspiration. Wentz was still ranting and raving. The others stood gloomily about, listening dejectedly.

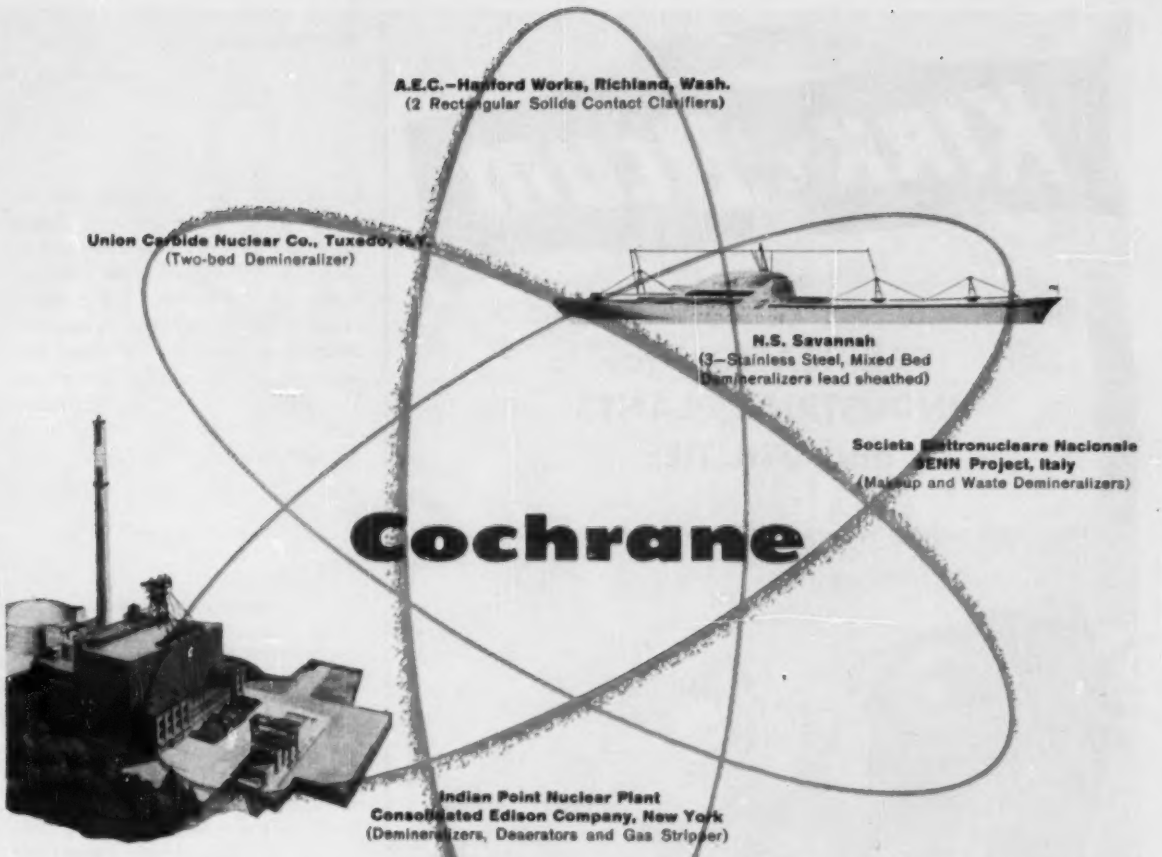
"Where's my 300 goldfish?" roared Marmy, unzipping his boiler suit as he started to shed.

"What?" howled the super incredulously, "you've flushed that gremlin already and we've been bird-dogging it for over a month?"

"Yes, I lit hot on its track first thing," chuckled Marmaduke good-naturedly. "Your chilled H_2O is short-circuiting in the coils. She has one inlet header with two connections for two inlet lines, and one outlet header for two outlet lines. These lines should have been paralleled, but they're cross-connected. It'll take you only a few minutes to disconnect the lines and hook them up as they should be."

"How did you discover that boo-boo?" asked Barber bug-eyed as he ogled Marmy suspiciously.

"You can't shoot trouble through the seat of your pants from blueprints alone," sounded off Marmaduke in



. . . Cochrane's experience with water helps to harness the atom

On land or sea, one of the essentials in converting atomic energy into usable power is ultra-pure water. Steam generation, reactor cooling, decontaminating of radioactive wastes and many other applications require special water treatment plants.

Cochrane was able to draw on nearly a century of experience in industrial water conditioning to meet the needs of the first atomic power plants. Increasing skills in nuclear applications are now making possible the solution of new and complex water treatment problems, including the automatic filling, emptying, and operation of complete demineralization or deionizing systems by remote control.

An indication of Cochrane's contribution to nuclear power development is given by the following list of projects undertaken since 1953:

Uranium Manufacture
3 Demineralizers
4 Filters
1 Deaerator

Experimental Work on Nuclear Reactors
1 Zeolite Softener
1 Acid Feed
1 Decarbonator

Nuclear Aircraft Development
2 Demineralizers

Nuclear Ship Propulsion
2 Demineralizers

Pressurized Reactor Tests
3 Demineralizers

Nuclear Ship Fleet Escort
2 Demineralizers

Nuclear Test
1 Vacuum Deaerator

Nuclear Ship Reactor Prototype
1 Deaerator

Nuclear Ship Fleet Escort
2 Deaerators

Nuclear Test Work
1 Vacuum Deaerator

Nuclear Tests
1 Vacuum Deaerator

Nuclear Aircraft Carrier
4 Marine Deaerators

Nuclear Destroyer
1 Marine Deaerator

Nuclear Destroyer
2 Marine Deaerators

4 Public Utilities
Demineralization Plants

Nuclear Research in Italy
6 Demineralizers
2 Zeolite Softeners

Nuclear Submarine Tender
3 Demineralizers

Nuclear Submarine Tender
3 Demineralizers

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Marmaduke

Begins on page 178

his gravelly voice, snapping shut his bag. "You got to get your hands dirty and use your ears and nose besides. All I did was feel the inlet and outlet chilled-water lines before crawling all the way back to the coils. Both those lines are the same temperature, so I knew what was wrong. I've seen too many short-circuited coils in air-handling systems to be stumped for long."—*SME*

Marmy's mailbox

PERPETUATE MARMY?

Thanks for the check for my Marmaduke idea in Sept 1960 POWER. I have been a subscriber for many years and an avid reader of Marmy since its inception. So it gives me great pleasure to feel that I have helped perpetuate him, something I'm sure a lot of people want to see done.

L A WATSON, *Atlanta, Ga.*

THERE IS A MARMY

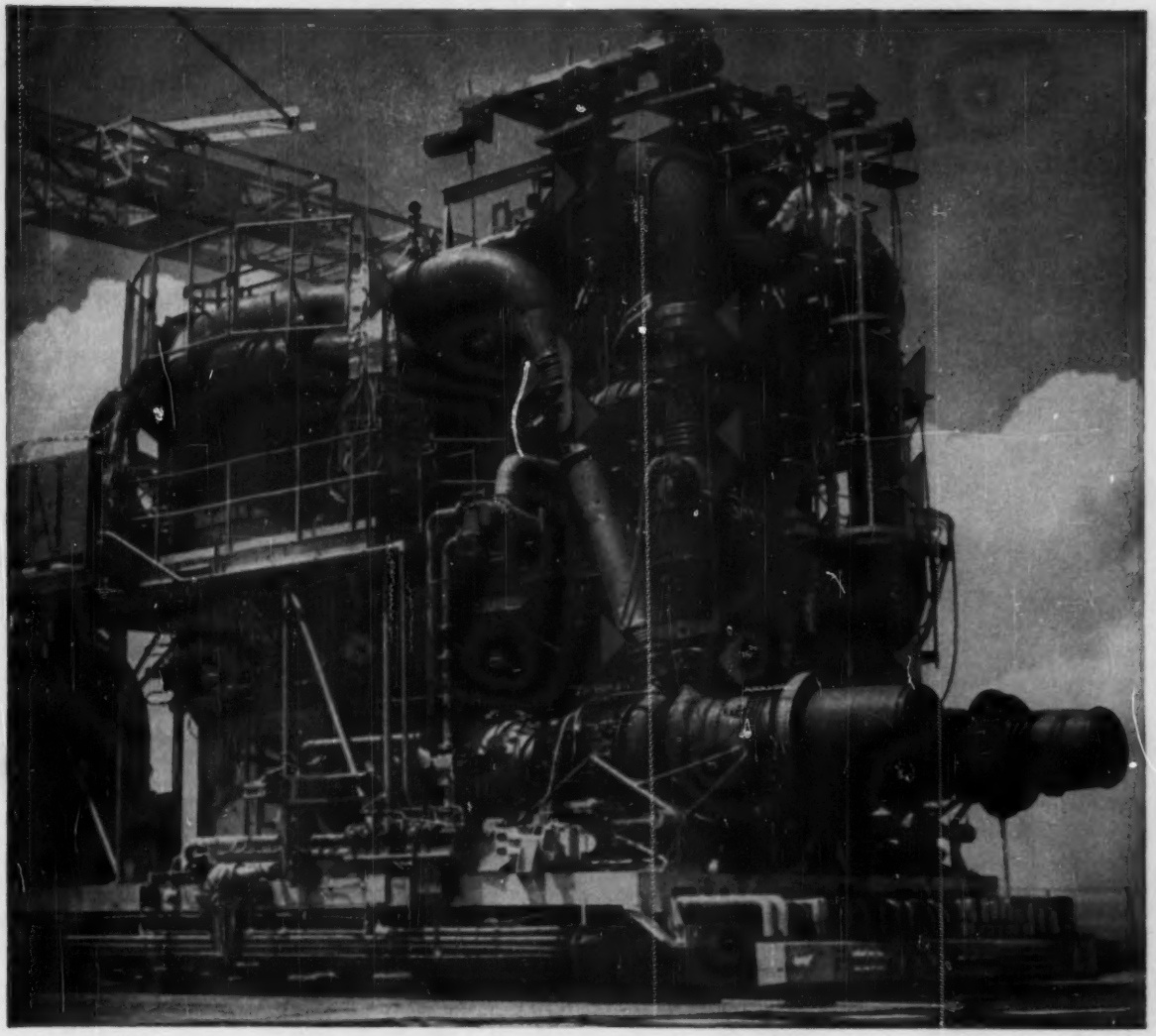
After reading the Marmaduke yarns for years, I still wonder if some of your readers take him to be real. Or is it the American way of going along with a gag—I'm referring to the tone of some of these Mailbox letters.

Most of his ideas are sound; some don't make sense. Why should supers, chiefs, etc be such dummies? Surely some of them have enough sense to think out solutions for themselves.

T FRASER,
N.S.W., Kogarah, Australia

EDITOR'S NOTE: *Marmy's comment: "Tell Mr Fraser to read a few issues of any machinery insurance magazine and see the millions of dollars—and the lives—that are lost through bonehead stunts. The guy who said 'truth is stranger than fiction' must have worked around a power plant. No wonder industry is putting in automation like crazy—it's more dependable than humans."*

For more facts circle 299 on Reader Service card, p 139



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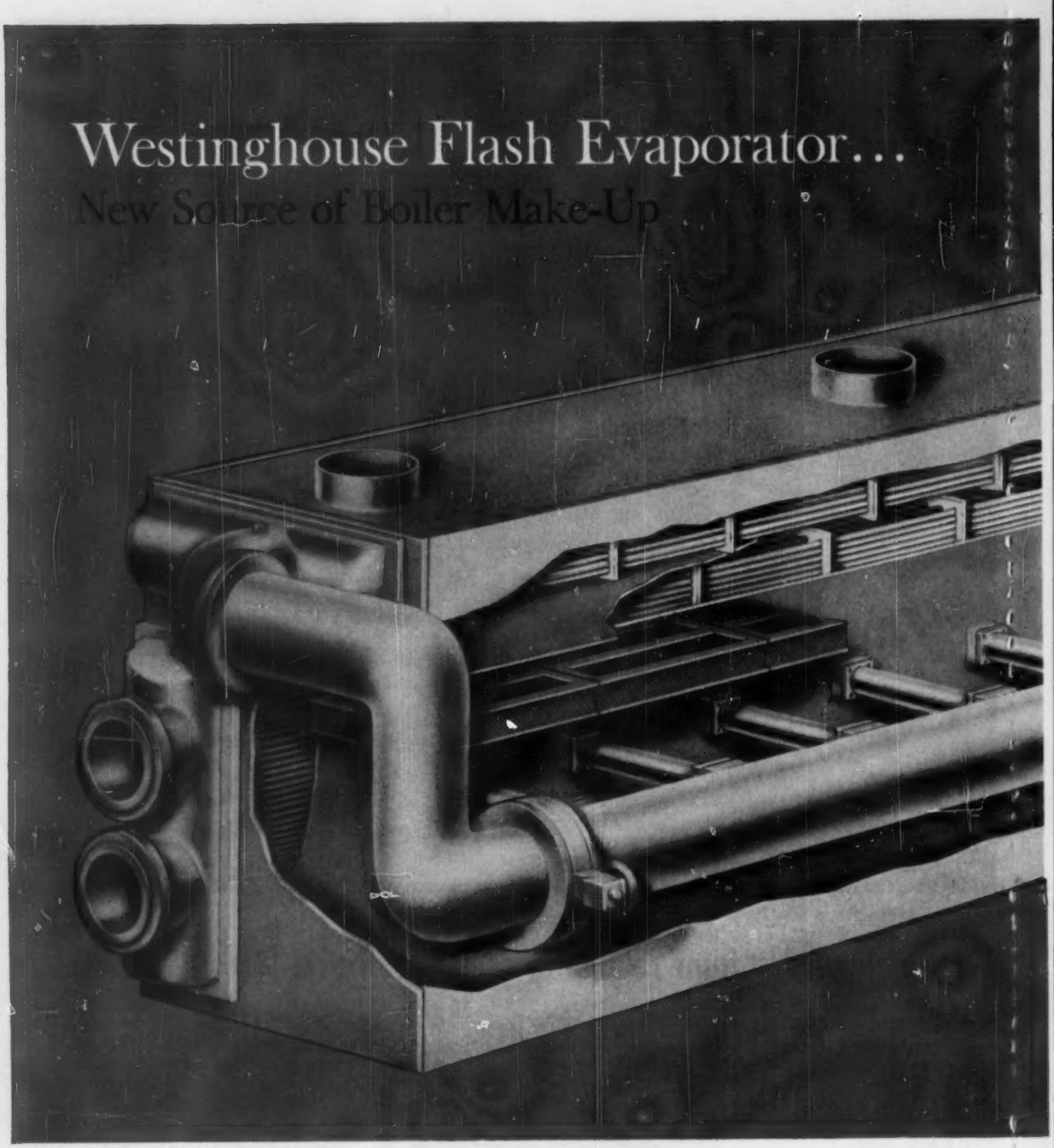

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Powerscope . . . A selective look at

New record orders

The Tennessee Valley Authority has announced the taking of bids for two 800-mw steam-turbine-generator units. The first unit must be ready to run by September 1, 1964 and the second by September 1, 1965. The site of the plant will be either southeastern Kentucky or east Tennessee. TVA has taken option on 60,000 acres of coal land in Kentucky as a fuel source. Largest steam units under way are two 650-mw units being built for TVA's Paradise Steam Plant in West Kentucky. (*McGraw-Hill World News*)

New pumped-storage plant

Pennsylvania Electric Company and Warren Electric Cooperative, Inc propose to build hydro plants on the Allegheny River in Warren County, Pa. PE wants to build a pumped-storage project pumping water from the Allegheny River Reservoir to a high-level reservoir yet to be built. Warren wants to build a low-level plant to use water released from the Allegheny River Reservoir. PE would run both plants as a system.

Bare-hand hot-line work

American Electric Power Service Corporation has developed a method for its linemen to work on live lines, up to 380 kv, with bare hands. Linemen work while standing in a fiberglass bucket held by a truck-mounted insulated aerial boom. A metal-mesh lining in the bucket connects by clamps to the conductor on which the men work. This energizes the mesh and occupants to the line voltage. The insulated boom gives the men insulation protection to prevent short-circuit flow to ground. In conventional line work changing a 34.5-kv insulator on a wood-pole line took about five man-hours; new method needs only one-half manhour.

The Dalles Dam completed

The Dalles Dam powerhouse on the Columbia River in Oregon was completed October 28 when the 14th unit, 78-mw capacity, started generating power. The 14 units have a total capacity of 1119 mw; two auxiliary generators have a total of 13.5-mw capacity. There is space for an ultimate installation of 22 main generating units. *(McGraw-Hill World News)*

Edison Electric Institute reports

A total of 12.6-million kw will be added to the U. S. electric capacity during 1960 for a total of 175.9-million kw by year end. This is an annual increase of 7.7%. With an annual expansion of 7%, total capacity at end of 1963 is expected to reach 211-million kw. The December 1960 peak load for the utilities is predicted to reach 137-million kw; in 1963 this is expected to reach 169-million kw. Reserve capability is expected to reach about 25% in 1963.

Thinking files—tomorrow?

The National Science Foundation has awarded a $68,400 contract to The Electrada Corporation to make an exploratory study of files that can sort and classify great masses of scientific data automatically. Previous contracts generally went to colleges and universities. A team of scientists, psychologists and engineers has been assembled to study the physiological and psychological aspects of human memory—the most highly developed filing system known. One major area of investigation will be the basic interrelation of information and the time needed for its useful retrieval and retention.

Power shortage up north

South-central Alaska may have a critical power shortage during the next decade. Studies by the Chugach Electric Association, Homer Electric Association and Matanuska Electric Association suggest that low-cost power could be obtained by installing gas turbines in the Kenai Peninsula oil fields to burn waste gas from the wells. Meanwhile, the Alaska Power Company, now being formed, has offered to supply the City of Anchorage with electric energy by the same method. Initially they would install 8.5-mw capacity, expected to grow to 14 mw by 1968. The city now pays 6 mills per kwhr for hydro power; the new gas-turbine energy would cost 5.5 mills. In 1970 the city's peak is expected to grow to about 36.3 mw. The CEA study shows that the total area would have a peak of 120.7 mw by 1970. *(McGraw-Hill World News)*

Researching shaft seals

Battelle Memorial Institute has started a major research program on the factors involved in the design and use of high-speed rotary-shaft face seals. More than a dozen large manufacturers interested in advancing shaft-seal technology are jointly sponsoring the program. Shaft seals of 50,000 to 100,000 rpm and higher are now designed for modern turbocompressors—the sealing problem becomes critical as high-speed turbo-

this month's power-field happenings

By B G A SKROTZKI, Associate Editor

equipment gets more widely used. The present 1-year program will study the dynamic behavior of high-speed liquid-lubricated face seals. Basic data will be collected on seal performance, with special emphasis on the behavior of the primary seal elements. Data analysis will make it possible to evaluate the importance of the various parameters.

World adopts new length standard

The meter bar which served as the length standard for over 70 years has been replaced by a wavelength of light. The action was taken by the 11th General Conference on Weights and Measures which met in Paris last month. The new definition of the meter is 1,650,763.73 wavelengths of the orange-red line of krypton-86. The wavelength of the specified light is believed to be immutable and reproducible with great accuracy by any well-equipped laboratory. The inch now becomes equal to 41,929.399 wavelengths of the krypton-86 light. The new definition shortens the distance from coast to coast between a point in New York City and a point in Washington by less than three in. The Conference confirmed the definition of the second of time as 1/31,556,925.9747 of the tropical year 1900 instead of 1/86,400 part of the mean solar day.

Russian gas

The U.S.S.R. says it has 700 scientists and engineers working on coal gasification. It has been using this as an industrial fuel source for 15 years. Present operations at the Moscow station produce 1-million cubic meters of gas per day. Several others are also running at other points in the U.S.S.R. Fuel cost with this method is claimed to be only 40% of cost of usual mining operations. A plant to produce 7-million cubic meters per day is being built—larger ones are in design. Oxygen or air is pumped down drill holes 75 to 100 ft apart into the coal seams to distill the coal in place. ***(McGraw-Hill World News)***

New atomic clock

Three Harvard scientists have built a new kind of atomic clock that promises to be over 100,000 times more accurate than the best atomic clock now running. The device uses a "bouncing box" that stores high-energy-level hydrogen atoms long enough for them to emit radiation of exactly 21-cm wavelength. The clock can be used both as a sensitive amplifier and as a source of 21-cm radiation of unprecedented stability and purity of tone. The nearly perfect monotone it emits promises to be the most accurate timepiece in the world. A second clock is being built to check the first one for accuracy which is expected to be one part in a million billion.

Science talent search under way

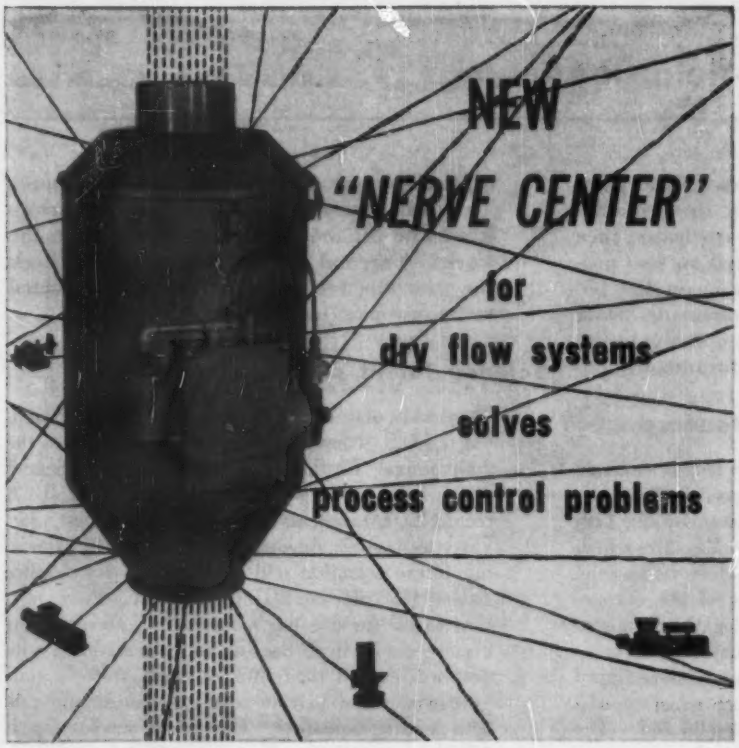
Thousands of high-school science seniors throughout the U.S.A. have been invited to compete in the 20th annual Westinghouse Science Talent Search for awards and scholarships totaling $34,250. A record 29,000 students entered the Search last year. Forty teenagers judged as the nation's most promising future scientists will attend the 5-day Science Talent Institute in Washington, D.C. early next year to vie for five top scholarships. During their expense-paid trip to the Institute the national winners will exhibit their own research projects, tour government and private research centers and talk with leading scientists. The grand scholarship is $7500; four others range from $6000 to $3000. Each of the other 35 competitors will get $250.

French automated power plant

Electricité de France has bought two RW-300 Digital Control Computers from the TRW Computers Company to control its new steam-generating plant to be built at Saint Ouen, France. More than 600 process variables will be automatically recorded and monitored by the computers. They will also calculate and record theoretical and actual performances and control operation to give energy output at minimum cost. The RW-300 is a transistorized digital computer with built-in analog-to-digital conversion equipment, a magnetic drum memory, of modular construction.

New co-sponsors

The Industrial Electrification Council, run since 1951 by the electrical utilities and several individual electrical manufacturers, will be co-sponsored by the Edison Electric Institute and the National Electrical Manufacturers Association starting January 1, 1961. The council initially was concerned with promoting electrical heat in industrial processes by offering application courses for utility customers and holding biennial industrial conferences. The Council will now include factory electric-distribution systems; it will soon release a course on plant distribution of electricity. Headquarters of the Council will remain in the offices of the EEI, 750 Third Avenue, New York, N. Y.



The new W&T Massometer® senses flow in closed systems. It measures dry, free-flowing materials and translates the results into a 3-15 psi signal. The unit can be used to indicate or record. It also controls proportional blending . . . helps solve problems in all kinds of control situations.

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The Massometer is calibrated with any maximum output between 40 and 200 lbs. per minute. Maximum volumetric capacity is 6 cubic feet per minute. Repeatability within ±0.2% of full scale assures stable performance.

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Powerscope

Begins on page 192

Bob Marks returns to *Power* staff

After 18 months as sales engineer for Pfaudler Permutit, Inc, Robert H Marks returns to his associate editor desk on POWER. A well-known expert in fluid handling and water treatment, he can count over 12-years' engineering experience. Before joining POWER in '57, Bob was a POWER author on numerous occasions—he's no newcomer to the power field.

He holds a degree from Massachusetts Institute of Technology. In his spare time he's an active naval reservist and a member of ASME, ASCE. A native New Yorker, he now lives with his wife in Brooklyn, N. Y.

Computer goes to Danish colleges

Students of electrical engineering at the Technical University of Denmark are introduced to operation and use of the digital computer in their first year. Intention: equip the student to tell when a digital computer will be useful in solving his problem. Students are given ability to *formulate* problems for programming.

The course is optional at the beginning of the undergraduate student's career but sometimes before his final year he must study the computer. All Danish engineers study for 5½ years for a master's degree.

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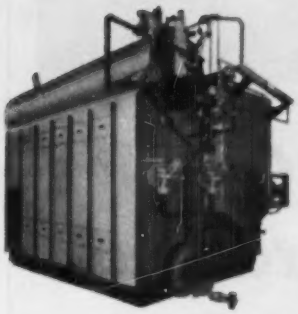

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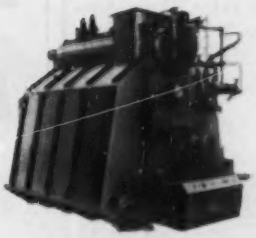

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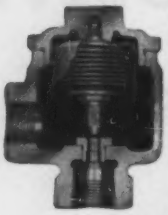

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circle 306 on Reader Service card, p 139

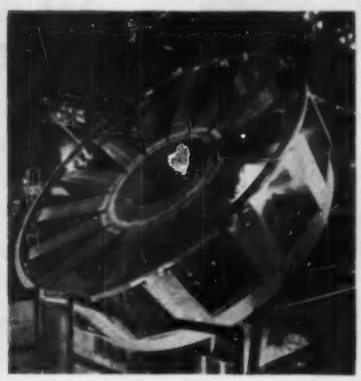
Powerscope

Begins on page 192

Optical-electrical device measures smoke density

Vienna, (*McGraw-Hill World News*) A Czechoslovakian engineer, J Karas of Kormorany power station, has developed a simple meter said to measure smoke density in Czechoslovakian thermal-power plants.

Device consists of a 6-v light bulb which mounts in the smoke stack or chimney. It throws a light beam through a glass plate to a photocell positioned opposite the bulb. Cell is hooked up with an amplification system to indicate the value. Amplification system, photocell and light-bulb strength can be altered to establish a reference standard to measure deviations.

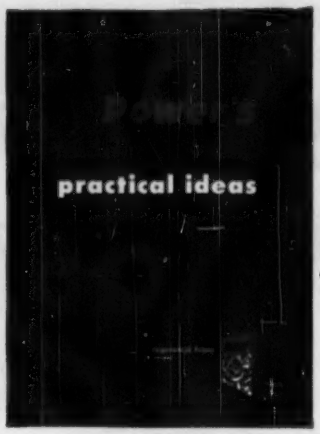


Bull Shoals spider captures two welders

Giant spider pictured above doesn't look ferocious. Actually he's lamely submissive while his two "captured" Allis-Chalmers workmen weld his appendages. Representing the first of two generators Allis-Chalmers is supplying for the expansion of Bull Shoals Dam, fabricated spider weighs 32 tons, is about 20 ft in diameter.

When completed, each of the two generator units will operate at 128 rpm, adding 47,368 kva to the dam's generating capacity. Four Allis-Chalmers hydraulic turbine-generator sets are already in operation at the dam. Although new generators are same physical size as the older units, the electrical output of each unit will

NEW!



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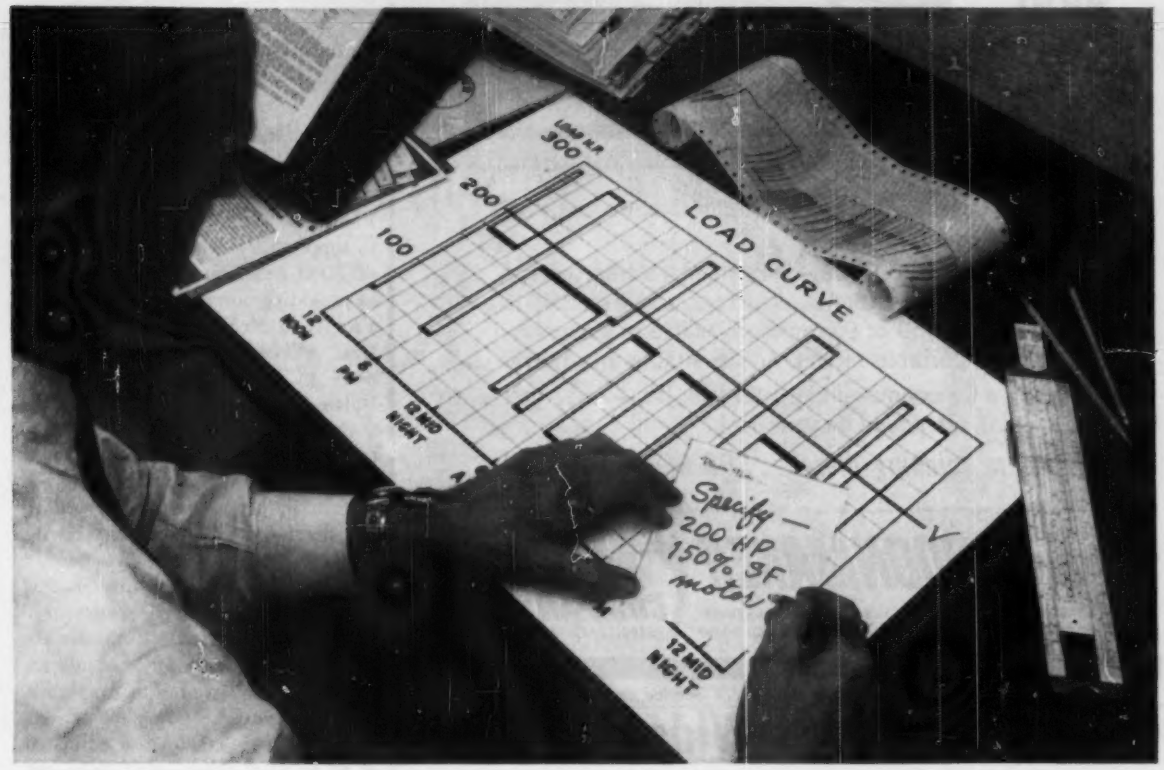

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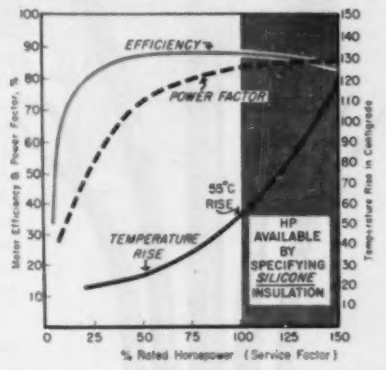

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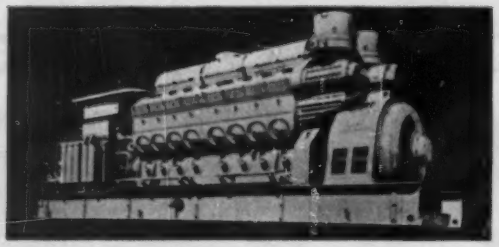

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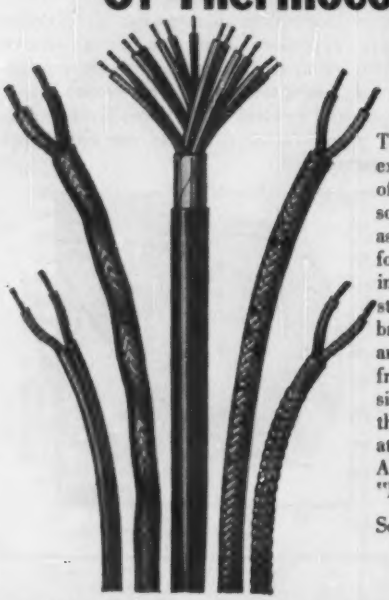
Choose From The Widest Variety Of Thermocouple Wires



Over 1500 Different Types

T-E's tremendous variety of thermocouple extension wires assures you quick delivery of every type and size—from one reliable source. Dependable quality control is also assured by T-E's own complete facilities for wire drawing, insulating and calibrating. T-E duplex wires come in solid or stranded construction, in all standard calibrations. The latest types of insulation and metallic armor overbraid protect them from all atmospheric, chemical and abrasive conditions. From 6 to 56 pairs of T-E thermocouple leads can now be installed at one time with the new "Thermo-Cable". Also available—a complete selection of "MIL"- Spec Wire.

See Our Full Line—

Write for Wire Bulletin 32WS-42

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.
Brampton, Ont.

Powerscope

Begins on page 192

be nearly 12.5% higher. Bull Shoals Dam, operating since 1953, is on north-central Arkansas' White River.

Antarctica gets first nuclear power plant

PM-3A, a 1500-kw reactor big enough to supply the average electrical needs of 3000 American homes, will soon be providing power for U.S. Naval Air Facility at McMurdo Sound, Antarctica. AEC selected the Martin Company to build the reactor for the isolated base.

Reactor will be a pressurized-water type, moderated and cooled with water. It will be assembled at the factory in packages and shipped to the site for erection and test operation.

Power generated by this reactor will save the government money over a span of years, Martin Company engineers say. About 80% of all air and ship transportation to Antarctica is fuel oil for diesel-power plants. It's difficult to deliver, with cost estimated at $1 to $3 a gallon—and ships can reach Antarctica only during a few months of the year. Summer population of 500 drops to 130 when all supplies must be delivered by air during the winter months.

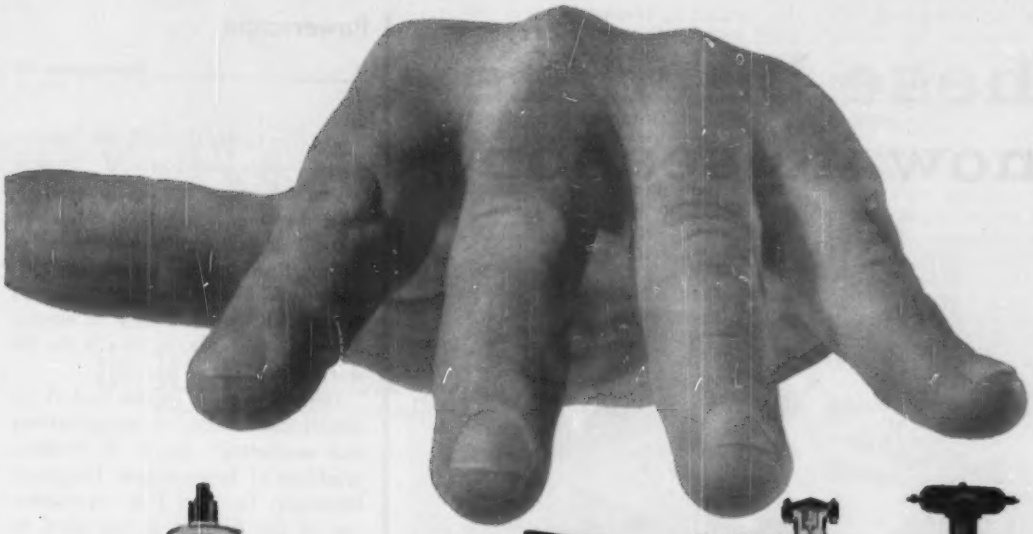
PM-3A will have a fuel core about the size of a 55-gal drum. One drum will do the job of millions of gallons of high-grade fuel oil, engineers explain, powering the plants for two years.

An ambitious production schedule is ahead for the Martin Company. Delivery is scheduled for Nov, 1961. Since the plant can only be installed during Antarctica's summer, delivery of the tested unit in November can mean an extra full year of production at McMurdo Sound.

International "yellow pages" covers 108 nations

If you're interested in checking on the status of abattoir equipment in Africa or planning a tour of South American zoological gardens, you

For more facts circle 309 on Reader Service card, p 139



SPLIT-BODY VALVES

LEVEL CONTROLLERS

PRESSURE REGULATORS

DIAPHRAGM CONTROL VALVES

KEEP A FIRM HAND ON FLUID CONTROL WITH K&M VALVES ALL ALONG THE LINE

From the complete display on the K & M shelf, you can select the best type of valve for every control job in the process line. You can, in fact, standardize entirely on K&M. That means simplified specification, ordering, maintenance.

Especially maintenance. K & M engineers have put consistent design emphasis on field interchangeability of components. In a pinch, you can "borrow" an inner valve or a topworks assembly from a pressure regulator for use with a diaphragm motor valve. That's what we mean by interchangeability.

And because the K & M line is so diverse and inclusive, our field representatives are free to make unbiased suggestions on the type of valve best suited to your requirements. That can often mean substantial dollar savings all along the process line.

THREE TECHNICAL BULLETINS GIVE THE IMPORTANT FACTS AND FIGURES. THEY'RE YOURS FOR THE ASKING.

Bulletin 401 Pressure-Regulating Valves

Bulletin 132 Split-Body Valves

Bulletin CV53 Standard Diaphragm-Operated Control Valves

K&M

diaphragm control valves

Our 79th Year

KIELEY & MUELLER, INCORPORATED

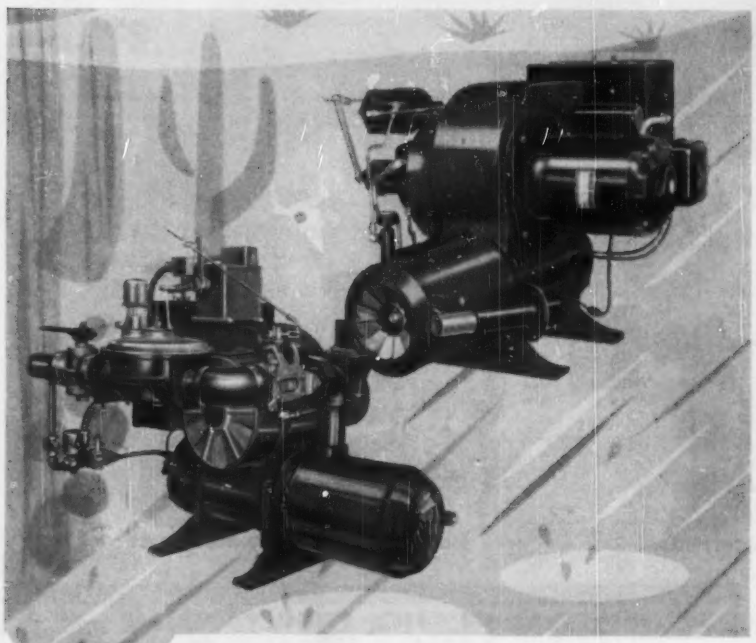
Oldest Pressure and Level Control Valve Manufacturer

64 Genung Street, Middletown, New York

B.A. 1731

For more facts circle 310 on Reader Service card, p 139

These burners know no season



Perfect mixture of air and fuel gives perfect combustion in any weather

HEV-E-OIL BURNERS furnish *all* the air necessary for combustion. This assures perfect fire control regardless of the weather or draft conditions. *Exclusive* metering pump measures oil in proper proportion to air . . . assures highest possible efficiency and highest return from your fuel dollar. Once the burner is set, it *stays* that way rain or shine! Complete package! Fire tested! Meets all codes! Electronic controls! Models from 5 to 150 gph.

HEV-E-DUTY POWER GAS BURNERS also provide their own air supply — without the aid of chimney draft. Air is metered in correct proportion to the amount of gas being used. And like HEV-E-OIL BURNERS, minimum-low fire and maximum-high fire can be controlled exactly to assure top efficiency for each individual boiler or furnace installation. Set it! Forget it, no matter what the weather. Sizes from 720,000 to 21,000,000 Btu. Also combination gas/oil models. Write Dept. P-120 for complete facts.

INDUSTRIAL COMBUSTION INC.

EXECUTIVE OFFICE: 4507 N. OAKLAND AVENUE
MILWAUKEE 11, WISCONSIN

Powerscope

Begins on page 192

might like to flip through the "yellow pages" — an *international* "yellow pages." A bright red 2-volume 2157-page directory lists names, addresses and phone numbers of almost half a million firms around the world. Perhaps you'd like to see what France is doing with ores, minerals or electrical equipment—again, this is the directory you'd turn to.

Described as "a unique tool of international trade, communications and marketing" by R A Nellson, president of International Telephone Directory, Inc and U.S. representative of the firm, it is published in Paris. Listings are in four languages —English, French, German and Spanish. The directory passes into the hands of over 34,000 businessmen and individuals with international interests. It has a paid circulation. The half-million firms take up 4500 business and professional categories. Category 269, for instance, *Electrical Equipment*, has 2808 listings in 58 nations.

Air conditioning pays for itself, survey shows

A survey conducted by Engineers, Inc shows that lowered productivity and time lost during hot weather account for losses of more than $100 per man per year in the average industrial plant. A similar study by the General Services Administration points up that only a 7-min saving in time per employee per day—an average $61 per year—will more than pay for the expense of an air-conditioning system.

Engineers, Inc studied a cross section of light manufacturing and assembly plants in the metropolitan New York area, considering both office and factory personnel. They aimed to determine differences in performance at temperatures above and below 71 F. They found that hot weather brought about absenteeism and a decrease in production. There were more work breaks, later starting and earlier stopping time for machines. On very hot days—total shutdown. They also discovered that there is some correlation between hot

D. I. S. STRIPS 10-INCH SCALE FROM 12-INCH PIPELINE IN JUST ONE DAY!

Dense scale deposits of oxides, sulfides and sulphur—10 inches thick in some places—clogged a 12-inch fuel supply line. Dow Industrial Service engineers stripped every trace of deposits from this 750-foot pipeline—restoring full capacity—in *just 24 hours!*

Solvents and a pipeline pig did the job. But for different conditions, D. I. S. uses other techniques to get the same result. For example, when scale blocked a 24-inch, quarter-mile-long waste line, D. I. S. engineers knocked out the deposits with a special D. I. S.-designed jet mole. Though this underground pipeline was buried 10 feet deep, D. I. S. cleaned it completely in only 16 hours!

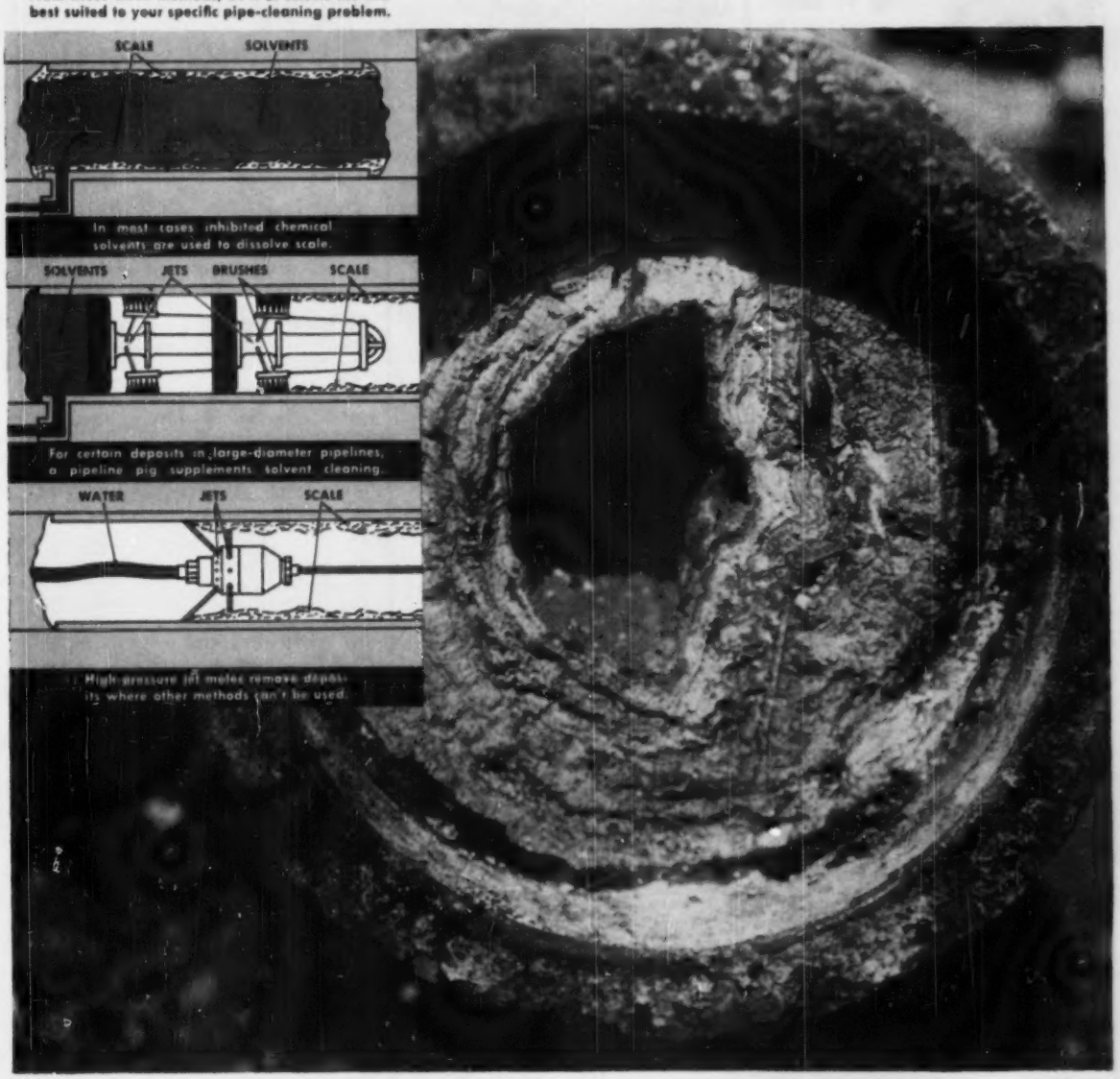
Nation-wide Dow Industrial Service first analyzes the job to be done, then selects the technique which will do the best job, fastest. D.I.S. cleans all kinds of lines—fresh water, boiler feed-water, gas, waste and other lines—and every kind of process and heat exchange equipment.

In addition, D. I. S. offers complete consulting laboratory service for water treatment and waste processing problems, backed by the technical resources of The Dow Chemical Company. For cleaning *any kind* of equipment, *anywhere* in the U. S., write or call DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW

DOW INDUSTRIAL SERVICE • Division of The Dow Chemical Company

From these three methods, D. I. S. selects the one best suited to your specific pipe-cleaning problem.



For more facts circle 312 on Reader Service card, p 139

MERCOID CONTROLS

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EXPLOSION-PROOF

WEATHER RESISTANT

GENERAL PURPOSE

Controls for—

- *PRESSURE*
  TWO-STAGE PRESSURE
  DIFFERENTIAL PRESSURE
- *TEMPERATURE*
  TWO-STAGE TEMPERATURE
- *LIQUID LEVEL*
- *MECHANICAL MOVEMENT*
  LEVER ARM AND FLOAT OPERATED
- *TRANSFORMER-RELAYS*

featuring:

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- Visible Contact

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MERCOID
CORPORATION,
4209 Belmont Ave.,
Chicago 41, Ill.

circle 313 on Reader Service card, p 139

Powerscope

Begins on page ?92

weather and accidents. Equipment damage was greater and there were more production rejects during summer months. All these factors dropped significantly when air conditioning was installed.

GSA survey results pointed out that there was a 9.5% increase in work production and 0.9% decrease in errors, 2.5% decrease in absenteeism after air conditioning.

Swedish firm gets contract for DAHE Reservoir Project

ASEA (Allmanna Svenska Elektrista Aktiebolaget) will supply the ten main transformers for DAHE located on the Missouri River near Pierre, S. D. The Swedish firm will design, manufacture and test the equipment. They're first electrical manufacturer of that country to receive a large award from a U.S. Government Agency.

Valued at $1,189,000, the contract is for one 103,000-kva 3-phase transformer, nine 68,677-kva single-phase transformers and spare parts. Final delivery expected: May '62.

DAHE aims to control flood waters as well as create water supply and electric power at a key point on the Missouri River. Power will be fed north to Bismark, N. D., south to Fort Thompson, N. D. ASEA is Sweden's oldest electrical concern.

"So you're short one transmission tower!"

New improved design of

JERGUSON Drain or Sampling Valve

Completely self-draining valve features freeze-proof outside screw and yoke bolted bonnet; perfect alignment

The newly improved design of the Jerguson No. 23 Drain or Sampling Valve uses a special-type bolted bonnet which assures perfect alignment and freeze-proof action.

Self-Draining: Valve stem seats on outside of valve body inlet; no liquid remains in nipple or valve.

New OS&Y Construction: Built for corrosive conditions where inside threads cannot be tolerated. Simplified Outside Screw and Yoke Bolted Bonnet . . . forged yoke supports stem away from valve body; separate forged gland-follower bears directly on packing, entirely independent of yoke.

Perfect Alignment; No Freezing: Design assures perfect alignment of valve, and prevents freezing by allowing stem to work freely at all times. Operates in normal direction with left-hand thread on stem.

Sizes; Pressures: Popular ¾" x ¾" size for 4000 lbs. @ 100° F. is standard with ½" plugged "steaming out" or purge connection. Other sizes: 1 x 1", 1½ x 1½", 2 x 2". Many optional features.

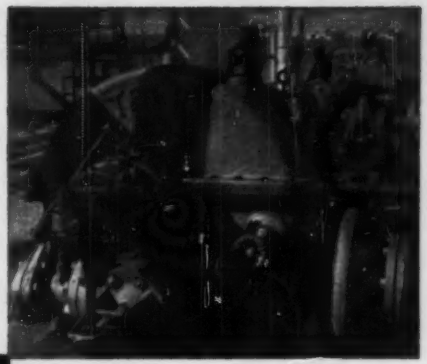
Write for data unit and complete details.

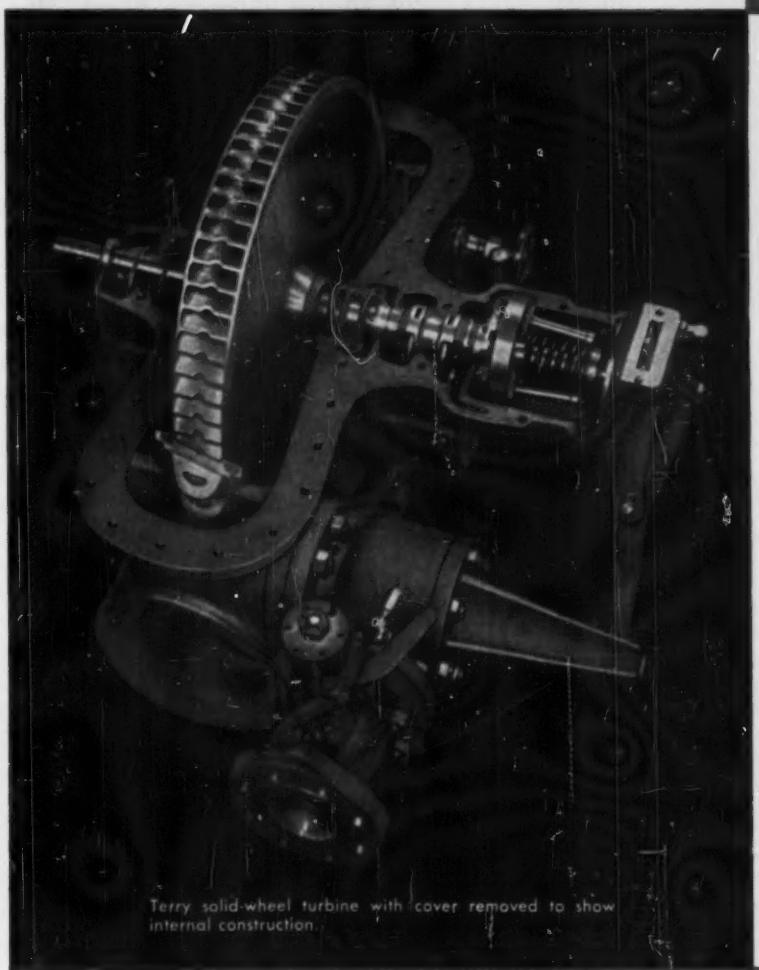
JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities

circle 314 on Reader Service card, p 139

TERRY SOLID-WHEEL TURBINE

spells service continuity for mechanical drives





Terry solid-wheel turbine with cover removed to show internal construction.

For mechanical-drive applications, such as these, you will never find the equal of Terry solid-wheel turbines for built-in dependability. They are *designed* for trouble-free operation under the toughest service requirements.

The wheel, for example, is a single forging of special composition steel. Unlike a built-up wheel, there are no separate parts to loosen or work out. The blades can't foul since they are double-rim protected...with one-inch clearances at either side.

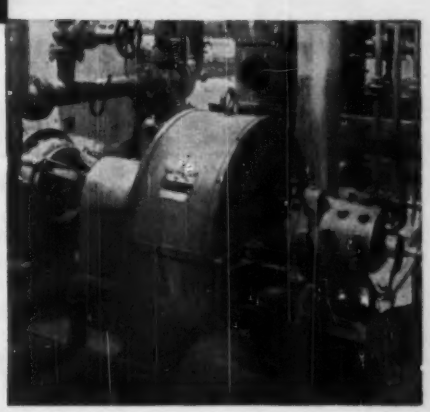
Any blade wear, which might occur after years of service, is of little consequence. As the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.

Specify Terry solid-wheel turbines for your next mechanical drives. They are available in capacities from 5 to 2,000 hp., speeds up to 10,000 rpm. Vertical turbines are built in sizes from 5 to 300 hp.

For full information about these reliable turbines, send for bulletin S-116.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY



TT-1216

For more facts circle 315 on Reader Service card, p 139

Calendar

Dec 12-14 — American Nuclear Society, Annual Winter Meeting, San Francisco, Calif. Details: Dr E Zebroski, General Electric Co, PO Box 254, San Jose, Calif.

Dec 12-15—Atomic Industry Exhibition, California Masonic Memorial Temple, San Francisco, Calif. Details: Atomic Industrial Forum, 3 E 54th St, New York 22, N. Y.

Dec 12-15 — Industrial Building Exposition & Congress, Coliseum, New York, N. Y. Details: Banner & Greif, 369 Lexington Ave, New York 17, N. Y.

Jan 17-19, 1961 — Instrument Society of America, Winter Instrument-Automation Conference and Exhibit, Sheraton-Jefferson Hotel, Kiel Auditorium, St. Louis, Mo. Details: Meetings Services Dept, ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

Jan 17-18—American Society of Lubrication Engineers, Bearing Symposium, Penn-Sheraton Hotel, Pittsburgh, Pa. Details: C L Willey, 84 E Randolph St, Chicago 1, Ill.

Jan 18—Metallurgical Society of AIME, Conference on Bar and Allied Products, Penn-Sheraton Hotel, Pittsburgh, Pa. Details: Metallurgical Society of AIME, 29 W 39th St, New York 18, N. Y.

Jan 23-26—Plant Maintenance and Engineering Show, International Amphitheatre, Chicago, Ill. Details: Clapp & Poliak, Inc, 341 Madison Ave, New York 17, N. Y.

Feb 13-16—American Society of Heating, Refrigerating and Air-Conditioning Engineers, 15th International Heating & Air-Conditioning Exposition, International Amphitheatre, Chicago, Ill. Details: E K Stevens, International Exposition Co, 480 Lexington Ave, New York 17, N. Y.

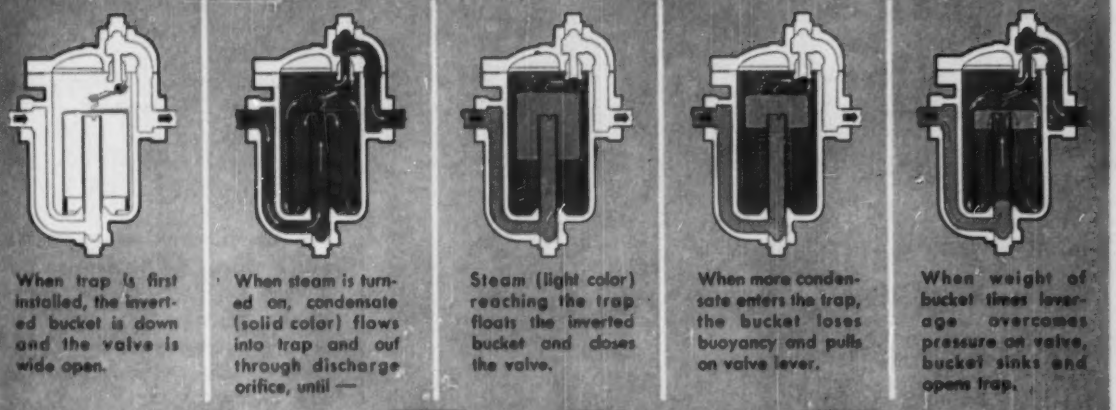
Feb 19-23 — American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, Chase & Park Plaza Hotels, St.

THE AIR IN THIS PLANT IS CLEANER THAN THE AIR A MILE ABOVE IT

The air in this plant has to be clean, because they make precision electronic parts here. It is the Collins Radio Company manufacturing plant in Cedar Rapids, Iowa . . . completely air-conditioned, and electronically air-cleaned with Westinghouse Precipitron®. Collins finds that clean, controlled air pays for itself in fewer rejects, more reliable products, and in reduced absenteeism. Write for our booklet describing the advanced air engineering concept Collins has adopted — based on Westinghouse air handling and air cleaning products. Dept. LP08, Sturtevant Division, Hyde Park 36, Massachusetts. YOU CAN BE SURE... IF IT'S **Westinghouse**

J-80708

This simple trap operating principle provides the efficiency, dependability and freedom from maintenance necessary for the most profitable use of steam


When trap is first installed, the inverted bucket is down and the valve is wide open.
When steam is turned on, condensate (solid color) flows into trap and out through discharge orifice, until —
Steam (light color) reaching the trap floats the inverted bucket and closes the valve.
When more condensate enters the trap, the bucket loses buoyancy and pulls on valve lever.
When weight of bucket tires leverage overcomes pressure on valve, bucket sinks and opens trap.
Key: condensate
steam
steam bubbles
air bubbles

ARMSTRONG INVERTED BUCKET STEAM TRAPS

are designed and made to give you these big benefits:

● Amstrong Traps, the first inverted bucket steam traps, now represent the most advanced development of this time-proven principle. They provide all the advantages necessary for efficient, economical condensate drainage from virtually all types of steam using equipment.

1. *No steam loss* – Steam never reaches the orifice even when there is no condensate load.
2. *Automatic air elimination* – Vent in trap bucket passes air and other non-condensibles through to be discharged with condensate.
3. *No cooling leg required* – Condensate is discharged at steam temperature as fast as it reaches the trap because trap operates on difference in density between steam and water not on temperature.
4. *Operates on any back pressure* – Failure of one trap in system will not cause others to open because high back pressure does not affect an Armstrong trap other than to reduce capacity. As long as there is a pressure differential across the orifice the trap will close on steam and open for condensate.
5. *Unaffected by ordinary dirt* — Swirling action of condensate keeps dirt in suspension until discharged with condensate, prevents it from lodging in valve.
6. *Completely dependable* — Proved design plus the use of all stainless steel working parts assure continuity of service and length of service unmatched by any other trap.
7. *Big capacity in a small, economical package* — Armstrong design gives you the highest practical capacity for any given pressure. And remember, Armstrong capacity ratings are based on *hot* condensate at the *working pressure differential* stated, not on theoretical orifice capacities.

Further information on these advantages plus much additional information is given in the 48 page Armstrong Steam Trap Book. Ask your local Armstrong Representative or write direct.

860 Series for low pressure heating service.

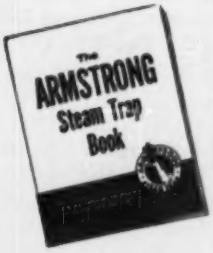
800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.



The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

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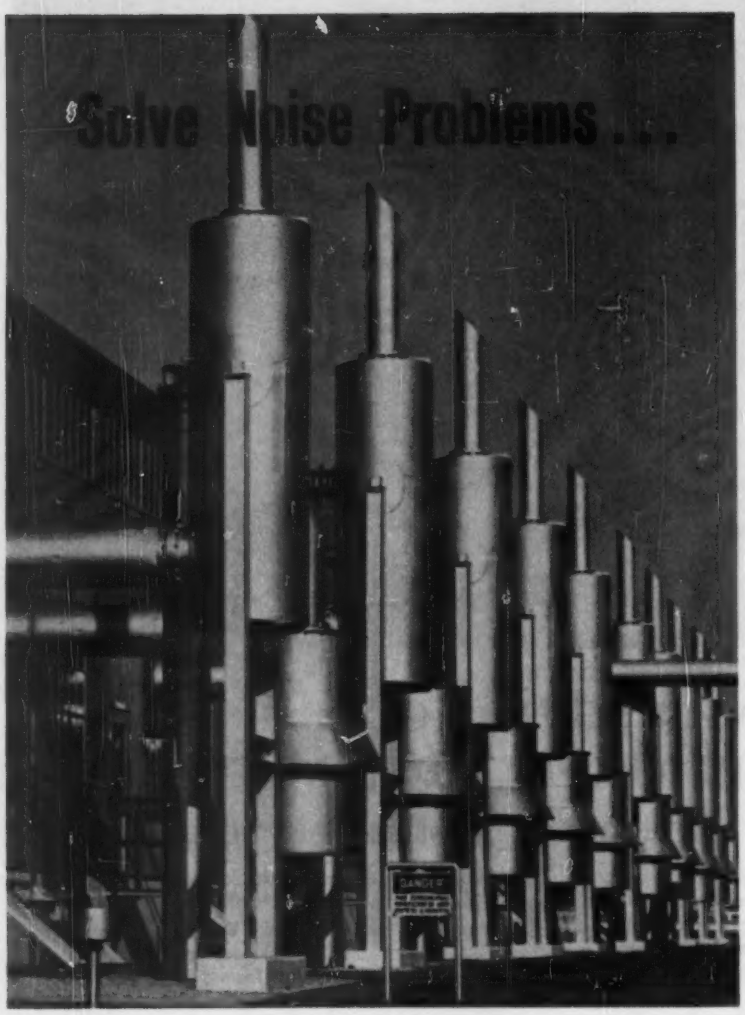
See our Catalog in Sweet's Plant Engineering File.



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There's no need to go-it-alone when your design problem deals with noise suppression. You can save time and money by putting a MAXIM engineer on your team.

He is a specialist in designing silencers to meet noise problems of all types of engines from giant diesels to "go-karts," as well as special purpose silencers for jet aircraft, atomic submarines, waste disposal plants, chemical plants and heat recovery applications.

Let us know your problems . . . we will work with your engineers . . . on your team . . . to solve them.

Immediate delivery on most standard type silencers from regional stocking points. Write or call today.

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Plants: Shreveport, Louisiana Clinton, Iowa

Sales agents in all principal cities and foreign countries.

Calendar

Begins on page 204

Louis, Mo. Details: AIME, 29 W 39th St, New York 18, N. Y.

Feb 26-March 1—American Institute of Chemical Engineers, Meeting, Roosevelt Hotel, New Orleans, La. Details: AIChE, 25 W 45th St, New York 36, N. Y.

Feb 26-March 2—Annual Meeting, Metallurgical Society, Society of Mining Engineers, Society of Petroleum Engineers — AIME, Ambassador and Chase-Park Plaza Hotels, St. Louis, Mo. Details: AIME, 29 W 39th St, New York 18, N. Y.

March 5-9—American Society of Mechanical Engineers, Gas Turbine Power Div, 6th Annual Gas Turbine Conference and Products Show, Shoreham Hotel, Washington, D.C. Details: C V Corbin, 20 Vesey St, New York 7, N. Y.

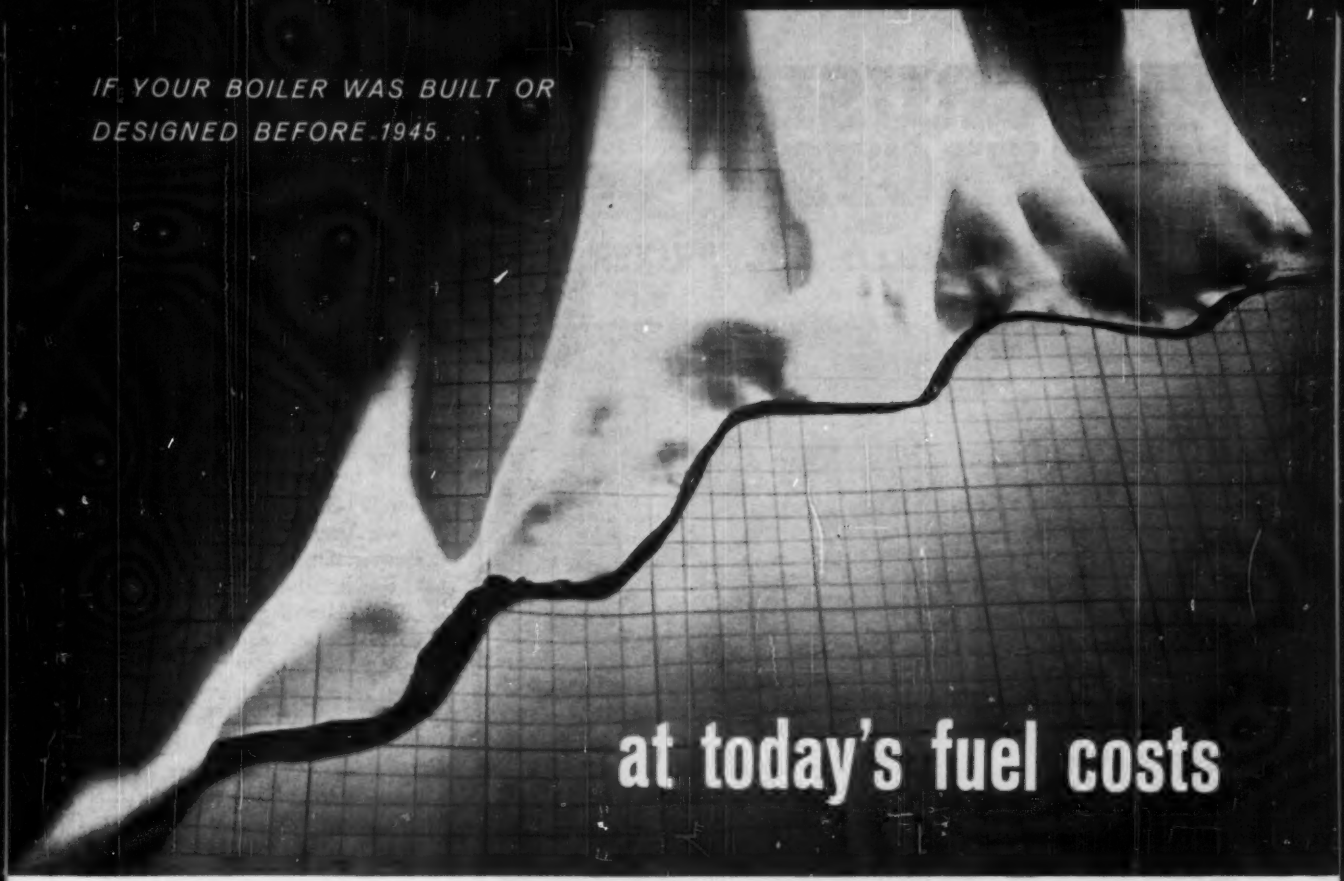
March 8-10—Instrument Society of America, 11th Annual Conference on Instrumentation for the Iron & Steel Industry, Roosevelt Hotel, Pittsburgh, Pa. Details: R R Webster, Jones & Laughlin Steel Corp, Research Lab, 900 Agnew Ave, Pittsburgh 30, Pa.

March 13-17—National Association of Corrosion Engineers, 17th Annual Conference and Show, Hotel Statler, Buffalo, N. Y. Details: T J Hull, 1061 M&M Building, Houston 2, Texas.

March 20-24—American Society for Metals, Western Metal Show, Pan Pacific Auditorium, Los Angeles, Calif. Details: J C Nelson, Metals Park, Novelty, Ohio.

March 21-23—American Society of Mechanical Engineers, American Power Conference, Sherman Hotel, Chicago, Ill. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

March 21-30—American Chemical Society, National Meeting, St. Louis, Mo. Details: R Avery, American Chemical Society, 2 Park Ave, New York 16, N. Y.



you may be paying for it a second time!

Are you operating a boiler that was designed in the day when fuel costs were much lower? Just since World War II, fuel prices have soared. And these higher costs put a premium on "little" inefficiencies that might have been ignored when your boiler was built.

Conversion is not the answer. You cannot buy efficiency in a boiler designed for solid fuels simply by switching to a conversion-type oil or gas burner. The answer is a *truly* packaged Cleaver-Brooks boiler — with all components designed to work together — fully factory-assembled and fire-tested.

To further provide and maintain top efficiency, modern Cleaver-Brooks packaged boilers offer a combination of fuel-saving design standards that cannot be found in any other boiler — at any price.

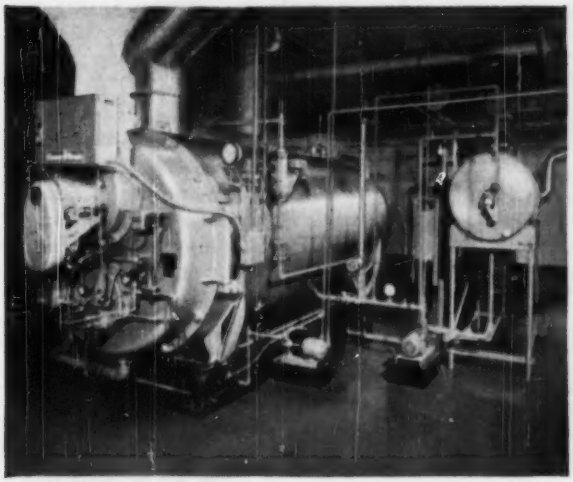
This combination of features — *four-pass design, forced-draft combustion, updraft construction and all the advantages of five square feet of heat-transfer surface per boiler horsepower* — puts your fuel costs down where they belong.

All this is provided by Cleaver-Brooks in the most compact, automatic packaged unit on the market. Sizes through 600 hp . . . oil, gas and combination oil-gas firing . . . larger sizes in Cleaver-Brooks Springfield water-tube boilers. *All* models are expertly started for you by a trained field engineer.

See your local Cleaver-Brooks agent for more detailed information, or write for the booklet, *How to Select a Boiler.*

GETTING MORE HEAT FOR THE FUEL DOLLAR

The W. T. Rawleigh Company, manufacturer of toiletries, medicines and food products for the home and farm, replaced two old firebox boilers in their Memphis, Tennessee, branch with one fully automatic, combination-fired CB boiler. Mr. James Trindle, office manager, reports: "Our records show . . . 36.4% less fuel consumed during winter months that averaged about 12% colder than the previous year. We're getting greater fuel economy than we expected."



Cleaver Brooks®

ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS

CLEAVER-BROOKS COMPANY

Dept. P, 301 E. Keefe Ave., Milwaukee 12, Wisconsin

For more facts circle 319 on Reader Service card, p 139

CRUSHING FACTS

from *American* PULVERIZER CO.

USER REPORT

"NO PARTS REPLACED IN 6 YEARS OF SERVICE"

The operation record at this municipal power station again proves the stamina and trouble-free performance of American AC Rolling Ring Crushers.

Although reducing ROM coal (up to 6" size) to ¾" this crusher has never needed a part replacement. Over 334,000 tons of coal have been reduced since installation.

The double life of the American-originated rolling shredder ring brought further economy. The rings, which split coal instead of crushing it, are reversible. After four years the rings were reversed to put the unused edges to work. This adds more years to their operational life.

Since 1908, American Pulverizer has manufactured reduction equipment exclusively. Every crusher is custom-built to meet your requirements and ruggedly constructed to give you the lowest possible cost per ton of coal reduced.

Our Engineering Department will help you with your reduction problem and recommend the proper equipment.

Complete Literature Available. State your tonnage requirements.

6012

American PULVERIZER COMPANY

ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS

1349 MACKLIND AVE. ST. LOUIS 10, MISSOURI

For more facts circle 320 on Reader Service card, p 139

Calendar

March 27-31 — National Symposium on Temperature—its Measurement and Control in Science and Industry, sponsored by American Institute of Physics, ISA, and National Bureau of Standards, Columbus, Ohio. Details: W R Tilley, NBS, Washington, D.C.

March 27-31 — Instrument Society of America, 3rd Symposium on Temperature, Veteran's Memorial Hall, Deshler Hilton Hotel, Columbus, Ohio. Details: Meetings Dept, ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

April 6-7—American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, New York, N. Y. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

April 9-13 — American Society of Mechanical Engineers, Oil & Gas Power Conference & Exhibit, Jung Hotel, New Orleans, La. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

April 10-11 — American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

April 10-12—American Institute of Mining, Metallurgical and Petroleum Engineers, Open Hearth & Blast Furnace Conference, Sheraton Hotel, Philadelphia, Pa. Details: AIME, 29 W 39th St, New York 18, N. Y.

April 10-21—American Welding Society, 42nd Annual Convention and Welding Exposition, Sheraton-Atlantic Hotel, Coliseum, New York, N. Y. Details: Information Center, AWS, 33 W 39th St, New York 18, N. Y.

April 17-19—Instrument Society of America, 7th National Symposium on Instrumental Methods of Analysis, Veterans Memorial Audi-

Begins on page 204

torium, Columbus, Ohio. Details: ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

April 23-26—American Society of Mechanical Engineers, Metals Engineering Conference, Penn Sheraton Hotel, Pittsburgh, Pa. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

April 26-27 — Metallurgical Society of AIME, National Technical Conference On H-T Materials, Pick-Carter Hotel, Cleveland, Ohio. Details: Metallurgical Society of AIME, 29 W 39th St, New York 18, N. Y.

April 30-May 3 — Electrochemical Society, Meeting, Claypool Hotel, Indianapolis, Ind. Details: Electrochemical Society, 1860 Broadway, New York 23, N. Y.

May 1-3 — Electric Association, Lighting Exposition, Lake Front Exposition Hall, Chicago, Ill. Details: Electric Association, 140 S Dearborn St, Chicago 3, Ill.

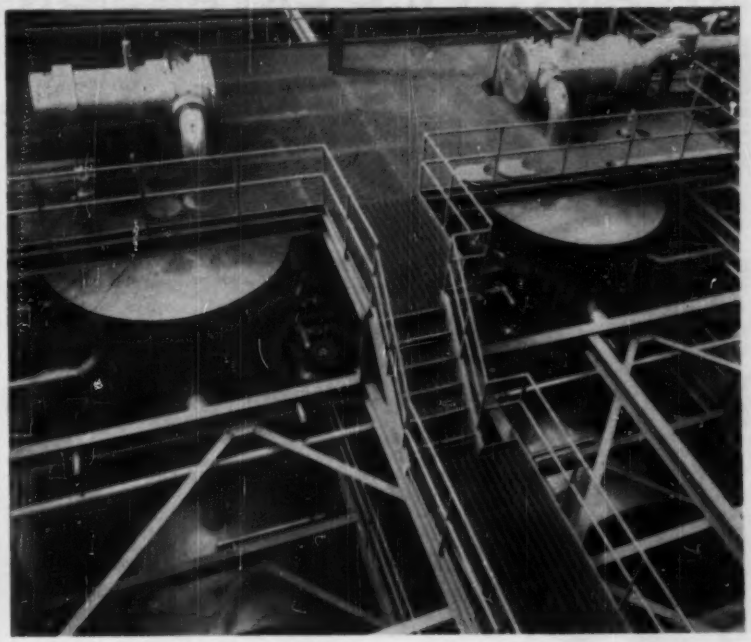
May 8-9 — American Society of Mechanical Engineers, Lubrication Symposium, Deauville Hotel, Miami Beach, Fla. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

May 7-10 — American Institute of Chemical Engineers, Meeting, Sheraton-Cleveland Hotel, Cleveland, Ohio. Details: AIChE, 25 W 45th St, New York 36, N. Y.

May 7-11—American Society of Mechanical Engineers, Hydraulic Conference, Queen Elizabeth Hotel, Montreal, Can. Details: ASME Meetings Dept, 29 W 39th St, New York 18, N. Y.

May 8-10 — Instrument Society of America, 4th National Power Instrumentation Symposium, LaSalle Hotel, Chicago, Ill. Details: Meetings Manager, ISA, 313 Sixth Ave, Pittsburgh 22, Pa.

FLUIDICS* AT WORK



How they're saving feedwater dollars at L.A.'s new Scattergood Steam Plant

Each of these two 12'-diameter, 1,036,230-lb/hr-capacity Permutit spray-type deaerators, nests atop its own 160,000-lb. storage tank in the new Scattergood Steam Plant at Los Angeles. The only open direct-contact-type heater with five closed heaters operating on the regenerative cycle, each deaerator operates at 20 psia to 52.8 psia. Design pressure is 100 psig, ASME code.

These deaerators process boiler feedwater for normal throttle steam conditions of 1800 psig at 1000° F with 1000° F reheat.

The City of Los Angeles can't afford to have corrosive oxygen or CO_2 in that water.

And it doesn't, because Permutit deaerators are *guaranteed* to remove all free CO_2 and to reduce oxygen to less than 0.005 m. per liter.

Save money

These deaerators save operating dollars because they have several advantages over tray or other types of deaerators. Maintenance is minimized, due to simplicity of design. Uniform, wasteless distribution of steam through water in scrubber, at *all* rates of flow from zero to full capacity. No water hammer, no rumbling—in short, quiet operation.

Besides these heaters, two more Permutit deaerators are used at Scattergood to prepare feedwater for evaporators.

Ultimately, Scattergood will have four generating units producing a total of 1,200,000 KW, almost equalling Hoover Dam. There's no room for boiler troubles in this kind of operation.

30-page bulletin

You can get the same feedwater purity and dollar savings, with Permutit deaerators (3000 to 3,000,000 lb/hr) and other water treatment facilities available through our Fluidics program. To start, send for our fact-filled 30-page bulletin, "Spray Type Deaerating Heater."

For more information, write PERMUTIT Division, Dept. PO-120, 50 West 44th Street, New York 36, N. Y., or call your local Permutit representative. In Canada: The Permutit Company of Canada, Ltd., 207 Queens Quay West, Toronto, Ontario.

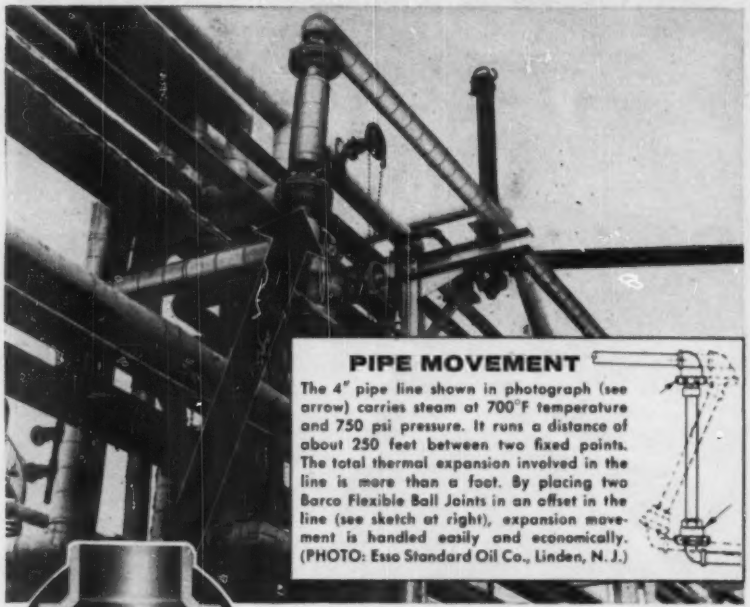
*FLUIDICS is a complete, imaginative Pfaudler Permutit program which economically provides practical answers to problems involving fluids and gases.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS...the science of fluid processes

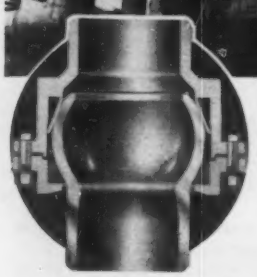
For more facts circle 321 on Reader Service card, p 139

How Plant Handles 700°F. STEAM . . . PIPE EXPANSION



PIPE MOVEMENT

The 4" pipe line shown in photograph (see arrow) carries steam at 700°F temperature and 750 psi pressure. It runs a distance of about 250 feet between two fixed points. The total thermal expansion involved in the line is more than a foot. By placing two Barco Flexible Ball Joints in an offset in the line (see sketch at right), expansion movement is handled easily and economically. (PHOTO: Esso Standard Oil Co., Linden, N. J.)



BARCO HT (HIGH TEMP.) Flexible BALL JOINTS

SAVE VALUABLE SPACE

ADVANTAGES:

SAVE SPACE—Barco Ball Joints are used to perform functions similar to U-bends or pipe loops—But with much less space required and often LOWER COST.

NO PRESSURE THRUST—Expensive anchoring or bracing not required to hold piping in place or in line.

HIGH TEMPERATURE, PRESSURE—Wide choice of materials in new Barco HT Joints.

SIMPLE—Easy to solve virtually any problem with aid of two or three Barco Joints.

The Barco HT (High Temperature) Flexible Ball Joint is a new development. It is *the key* to solving many PIPE EXPANSION PROBLEMS where high temperatures and pressures are encountered. The outer sealing gasket is a special, high temperature ring. The inner take up ring is self-adjusting to thermal expansion and maintains tight sealing action without building up high resistance (friction) to turning or angular flexing. HT joints can be supplied in sizes from 1" to 12", angle or straight, and can be fabricated from materials to withstand as much as 1000°F, 1200°F, or even 1400°F, under certain conditions.

Local Barco Field Engineers will be glad to give you full information and recommendations. Call or write today.

Send for this BULLETIN 31

"How to Solve Piping Flexibility Problems". Complete with piping layout drawings and illustrations. Shows how to cut costs, save time, and do a better job!

PRODUCTS BACKED BY EXPERIENCE BARCO FOUNDED 1908

BARCO MANUFACTURING CO.

522N Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints

In Canada: The Holden Co., Ltd., Montreal

For more facts circle 322 on Reader Service card, p 139

Appointments

New names

Anaconda American Brass Company: new name for The American Brass Co. **Burndy IEI de Mexico S. A.:** Mexican corp jointly owned by Burndy Corp and Ingeneria Electrica Industrial, S. A.

Electronic Data Processing Div: new name for Minneapolis-Honeywell Regulator Co's Datamatic Div. **Engineering Services:** engineering group established by Allis-Chalmers Manufacturing Co to strengthen link between basic research and product engineering and development. **TRW Computers Company:** new name for The Thompson Ramo Wooldridge Products Company.

Engineer changes

Allis-Chalmers Mfg Co: L G Ingwersen, R W Sherwood, S L Soloff, Industries Group; C L Brisley, chief industrial engineer; L M Dings Jr, chief production engineer. **Brooks Instrument Co, Inc:** P Des Marais, application engineer. **H G Acres & Co Ltd.** A J Gegan, executive engineer.

Hewitt-Robins, Inc, The Robins Engineers Div: F Tencza, chief engineer. **Hydromatics, Inc:** J A Wiedmann, chief engineer. **Sethco Mfg Corp:** M H Pollack, sales and development engineer. **Thatcher Furnace Co:** J H Dinehart, chief engineer.

Westinghouse research labs appoint two scientists to be associate directors—Dr J W Coltman, formerly manager of the electronics and nuclear-physics dept and Dr J K Hulm, formerly manager of the solid-state-physics dept. Coltman will head the central research program on advanced equipment concepts; Hulm will guide solid-state research program.

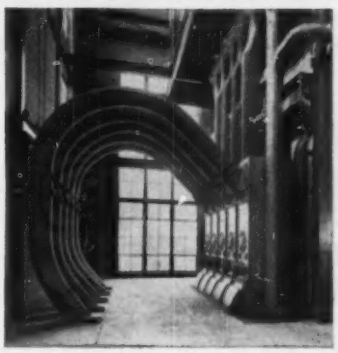
Born in Cleveland, Ohio, Coltman received his first degree from Case Institute of Technology. The University of Illinois awarded him his MS

P.F.I.
THE PIPE FABRICATION INSTITUTE

ONLY SHOP FABRICATION

OF POWER AND PROCESS PIPING

IN PFI MEMBER EQUIPPED AND MANNED SHOPS CAN PRE-DETERMINE COMPLETE ACCURACY IN MEETING ALL SPECIFICATIONS



Advanced design, processing improvements and progressive engineering all call for more exacting piping specifications.

In turn, this requires the best possible utilization of modern fabrication techniques.

Shop fabrication is the only positive way of meeting specifications involving accuracy in stress relieving, bending, coiling, post-heating, vanstoning, welding, fitting and testing.

Shop fabrication also assures the dependable scheduling of installation and erection work and, by avoiding hit and miss methods, it also proves more economical.

So insist on shop fabrication by the nation's leading piping specialists . . . the members of PFI.

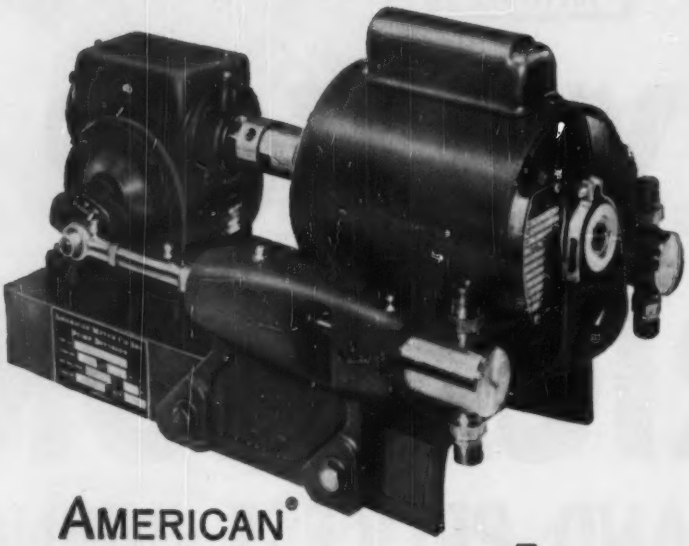
PIPE FABRICATION INSTITUTE · ONE GATEWAY CENTER · PITTSBURGH, PA.

Simply circle the Standards you can use and mail to PFI at the address above.

1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
3 Linear Tolerances Bending Radii
4 Shop Hydrostatic Testing
5 Cleaning Fabricated Piping
6 Built-up Weld, Metal Bosses
7 Welded Nozzles — Spacing
8 Preheat - Postheat Welding, Low Chrome — Moly Pipe
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices
11 Affixing Permanent Symbols to Piping
12 Preheat - Postheat Welding, Medium Low Chrome — Moly Pipe
13 Classification, Shop Testing, Inspection, Cleaning

For more facts circle 323 on Reader Service card, p 139

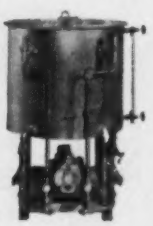
FEED CHEMICALS ACCURATELY!



AMERICAN®
METERING PUMPS

Series 100 pumps have repetitive metering accuracy of plus or minus 1% when operating between the limits of 10% and 100% of stroke length. Design simplicity assures dependable, economical water treatment. Screw adjustment on crank provides easy, accurate stroke regulation for capacities ranging from .65 gph to 13.10 gph at maximum pressure of 1000 psi on Series 100 Simplex model. Duplex models have double that capacity.

- interchangeable liquid ends
- spherical self-aligning bearings on crank and crosshead handle greater radial and axial thrust loads
- crossheads of hardened and ground steel ride on cast iron
- easily adjusted screwed packing glands
- heavy duty reducers
- NEMA frame motors
- nylon dust covers protect bearing surfaces



Available with standard feeder tanks of various sizes.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
pump division
13500 PHILMONT AVE., PHILADELPHIA 16, PENNA.

PUMP DIVISION

For more facts circle 324 on Reader Service card, p 139

Appointments

Begins on page 210

and PhD degrees. He invented with Dr Fitz-Hugh Marshall a scintillation counter, predecessor to the Geiger counter in detecting nuclear radiation.

Hulm is a native of Southport, England. He did his undergraduate and graduate work at Cambridge University. In 1949 he came to the U.S. as a research fellow in cryogenics at the Institute for the Study of Metals, University of Chicago. He was named assistant professor in physics in 1951 and joined Westinghouse Corp as a research scientist in '54.

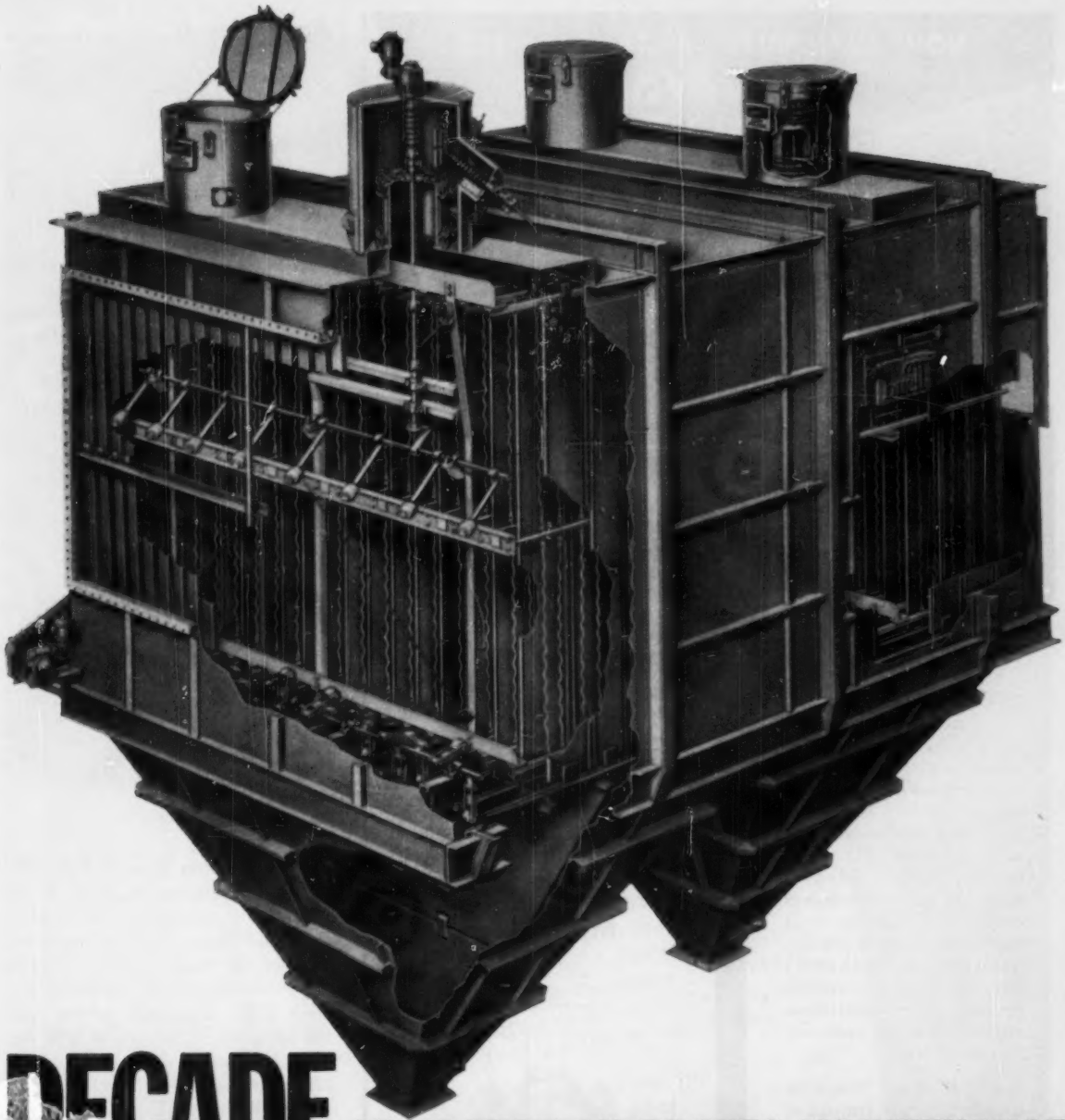
Management changes

Charles E Nelson Jr

Waukesha Motor Company's new president, C E Nelson Jr, replaces J E DeLong, president of the company for the past 25 years. DeLong retired from the company in October.

Nelson's earliest activities in Waukesha in 1929 were connected with the financial dept. He later became factory production manager and in 1949 the president's assistant. He was made a member of the board in 1951 and executive vice-president in 1957.

Nelson has been active for many years on the Executive Committee of the Int Combustion Engine Inst, Dept of Defense's Int Combustion Engine Industry Advisory Committee on Engine Standardization. continued



DECADE OF OPERATION PROVES MAINTENANCE OF BUELL 'SF' PRECIPITATORS AVERAGE LESS THAN 2%

In 10 years of selling 'SF' electric precipitators, the number of replacement parts ordered from Buell has amounted to only 1.17% of the total sales! Even on emitting electrodes, usually the most vulnerable part of a precipitator, replacement has amounted to less than 1% of the original number installed. What do these extremely low percentages mean? Exceptionally low maintenance costs, for one thing, continuous high-efficiency operation, fewer shutdowns and process interruptions. Buell self-tensioned emitting Spiralectrodes eliminate vibration found in weight-tensioned wires. Buell's low maintenance precipitators will provide you with the most satisfactory operating results. They're backed by 25 years of experience in dust collection, with the practical know-how gained on hundreds of installations. Write for descriptive literature. The Buell Engineering Company, Incorporated, Department 50-L, 123 William Street, New York 38, New York. Northern Blower Division, 6428 Barberton Avenue, Cleveland, Ohio.

buell Norblo

For more facts circle 325 on Reader Service card, p 139

NOW AVAILABLE . . . A STANDARDIZED
CONTROL VALVE

DESIGNED FOR THE
POWER INDUSTRY

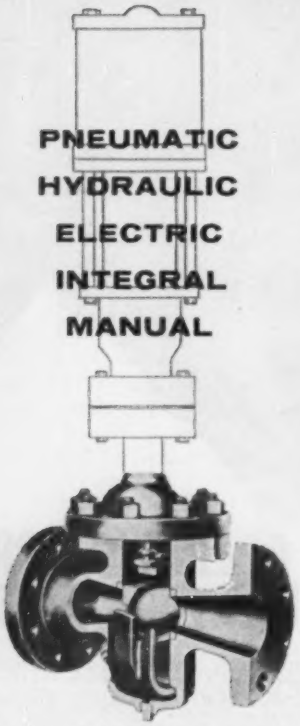
CAPABLE OF . . .

- HIGH PRESSURE DROP — to 6000 psi, one stage
- HIGH FLOW CAPACITY — almost twice the C_v of the same nominal size globe valve
- EXTREME TEMPERATURES — −420 F to +1800 F
- WIDE RANGEABILITY — 100 to 1 "turn down" or better
- TIGHT SHUT-OFF — regardless of temperature and pressure conditions.

The straight-through Venturi design coupled with the unique patented control element of the ball and cage makes the General Kinetics' P-K Paul Control Valve ideally suited to both routine and critical applications. It is highly resistant to erosion and abrasion, and it offers long life and elimination or reduction of down-time with a resulting economy in overall cost.

The P-K Paul Valve is available in standard sizes from ¼" to 14" in accordance with ASA Standards. Larger sizes are available upon request.

PNEUMATIC
HYDRAULIC
ELECTRIC
INTEGRAL
MANUAL



P-K Paul Venturi-Ball
Control Valve

Write today for our new 16 page
Technical Bulletin No. GV-101.

General Kinetics Corporation
197 South Van Brunt Street • Englewood, New Jersey
LO 7-3803 • TWX: ENGL NJ 1005

For more facts circle 326 on Reader Service card, p 139

Appointments

Begins on page 210

Retirements

G C Camilli, supervisor of product engineering for General Electric Company, after 36 years.

Dr G H Keulegan, National Bureau of Standards, after 38 years.

W J Schmidt, assistant vice-president of sales, Long Island Lighting Co, after 28 years of service.

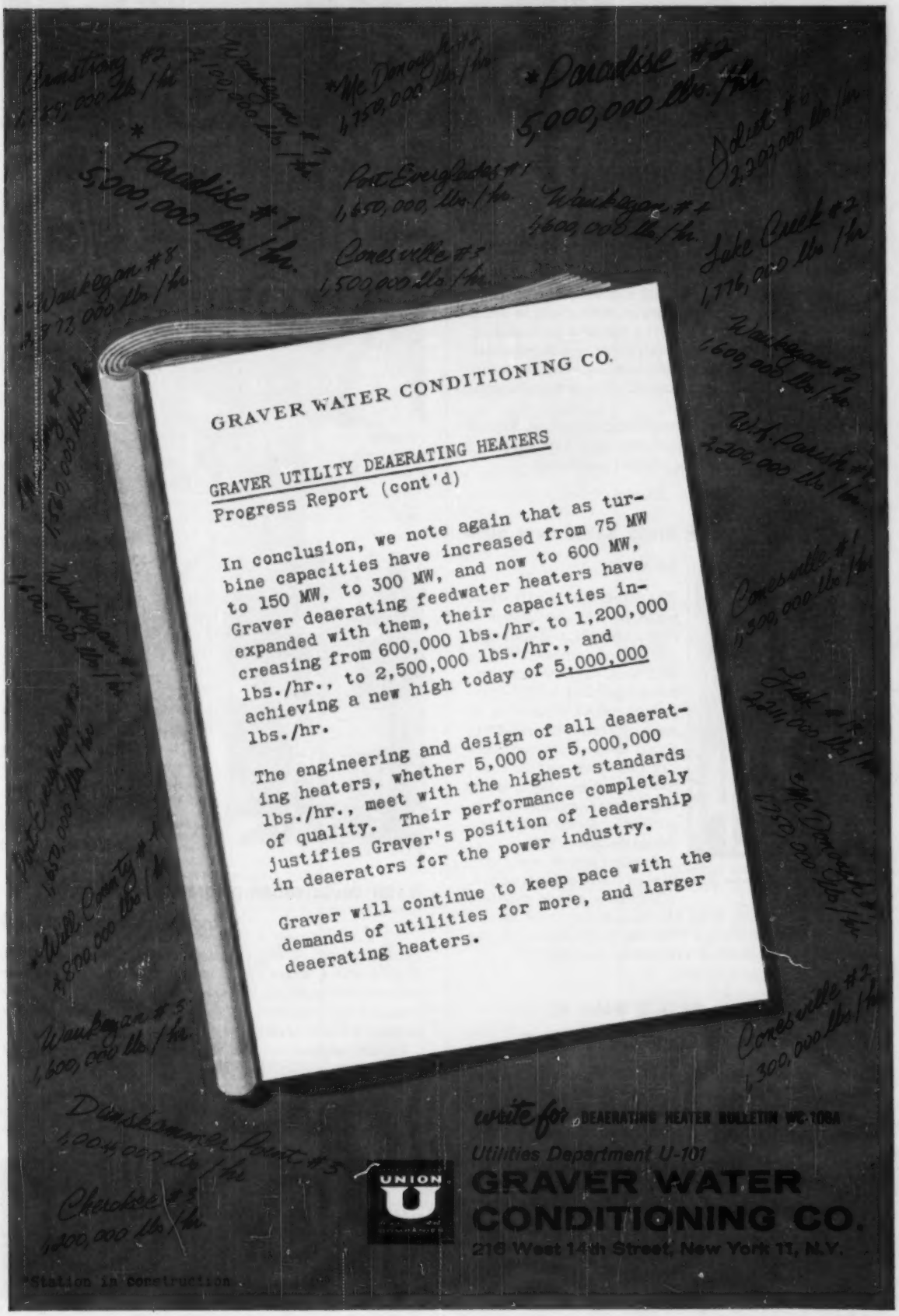
E S Dulin

Byron Jackson Div of Borg-Warner Corp announces their board chairman's retirement after three decades of leadership. He was president of the company from 1929 to 1958 and chairman of the board since 1945. E S Dulin retired from the company on Sept 1. He will continue his outside interests and maintain an office in Los Angeles' Statler Center Building. He is director of a number of California industries.

His company was one of the pioneers in the West, founded in California in 1872. In its 88-year history of operation it was led by four men: Byron Jackson, J B Keating who took over in 1913, Dulin, and A W Rose who succeeded Dulin as president in 1958. The company manufactures centrifugal pumps for the agricultural, power-generation, industrial, municipal and nuclear services.

Obituaries

Cyril R Bloom, supervisory engineer in Allis-Chalmers steam-turbine dept, on Sept 26.

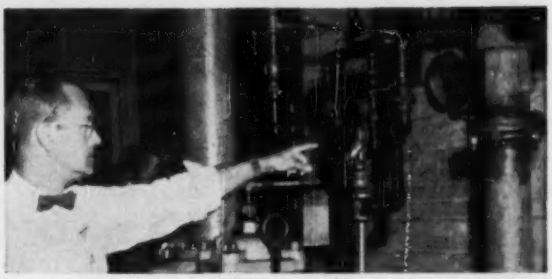

GRAVER WATER CONDITIONING CO.
GRAVER UTILITY DEAERATING HEATERS
Progress Report (cont'd)
In conclusion, we note again that as turbine capacities have increased from 75 MW to 150 MW, to 300 MW, and now to 600 MW, Graver deaerating feedwater heaters have expanded with them, their capacities increasing from 600,000 lbs./hr. to 1,200,000 lbs./hr., to 2,500,000 lbs./hr., and achieving a new high today of 5,000,000 lbs./hr.
The engineering and design of all deaerating heaters, whether 5,000 or 5,000,000 lbs./hr., meet with the highest standards of quality. Their performance completely justifies Graver's position of leadership in deaerators for the power industry.
Graver will continue to keep pace with the demands of utilities for more, and larger deaerating heaters.
write for DEAERATING HEATER BULLETIN WC-100A
Utilities Department U-101
UNION
GRAVER WATER CONDITIONING CO.
216 West 14th Street, New York 11, N.Y.

SARCO TOPICS

How to save water and prevent over-cooling of compressors, small engines, and hydraulic oil-coolers

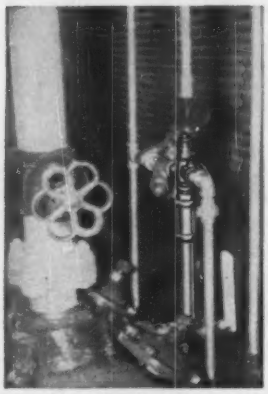
When cooling water is controlled manually the operator frequently leaves the valve nearly wide open, in order to play safe if the load varies. The result is over-cooling. If he attempts to vary the flow of water he risks the danger of under-cooling. Automatic cooling controls assure proper cooling at *all* times and effect important economies in water consumption.

And here are three different experiences at Revere Copper and Brass plants which may give you some tips on solving your own cooling control problems.



T-44 cooling control on compressor at Rome Manufacturing Co. Div. of Revere. Sarco sales representative Emile Strickland points to control installations.

How Revere Copper & Brass Saved over 50% on water



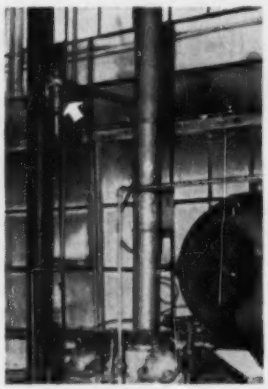
Sarco T-44 automatic cooling control installed at Revere's Riverside plant.

The Riverside, California, plant of Revere Copper & Brass was plagued by over-cooling of compressors. In addition, their water consumption was high — approximately 2,000 gallons an hour. By simply installing Sarco T-44 automatic cooling controls on the compressor cooling lines, plant engineers eliminated over-cooling and cut water consumption about 60%.

Another benefit was a saving in tool maintenance. (Originally excess moisture was causing difficulty with a large number of air screwdrivers used in the plant.) With the T-44's in service the maintenance problem has practically disappeared.

Manual control was wasting water at Rome Manufacturing Co. Div., Rome, N. Y.

At the Rome Manufacturing Company Division of Revere, at Rome, N. Y., cooling water for air compressors originally was manually controlled. When they installed Sarco T-44 automatic cooling controls on the cooling water lines they made substantial savings in water. They saved damage and maintenance cost on the compressors, too. That's because they eliminated the errors inherent in manual control. Automatic cooling controls always assure optimum cooling by permitting safe operation at the maximum temperature recommended for any given machine or process.



Installation of a Sarco T-44 on compressor at Rome, N. Y.

Water conservation program at Baltimore led to automatic control

Double target of engineers at the Baltimore plant of Revere was a water conservation program plus tighter temperature control. To achieve both objectives they installed Sarco automatic cooling controls on an air compressor, an aftercooler and a hydraulic oil cooler.

Results were so satisfactory they followed through by installing 50 additional Sarco controls.

For more information on cooling control, contact your Sarco Sales Representative, District office, or write — 2169

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

SARCO

Inside story on automatic cooling control

. . . for compressors, small engines, oil coolers, water-cooled rolls, condensers, water-cooled bearings, and other cooling applications.
Self-powered SARCO T-44
— no compressed air or electricity needed.

Simple, gadget-free design. Fully modulating. Sensitive liquid-filled thermostat gives you uniform movement of valve for each degree of temperature change, at all points on the range. Packless — no stuffing box — no leaks — no valve stem jamming. Self-contained — no part of mechanism exposed. Dependable and inexpensive — thousands in service. So reasonable in cost, you can afford Sarco automatic cooling controls for every application.

Sarco T-44 self-powered cooling control is available in standard 50° adjustment ranges: 60-110° F., 85-135° F., 110-160° F. and 135-185° F. Sizes: ⅜", ¾", ½" and 1".

For the full story on Sarco Cooling Controls...

contact your Sarco sales representative or district office, or write—

2168

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N.Y.
PLANT: BETHLEHEM, PA.

circle 329 on Reader Service card, p 139

Appointments

Begins on page 218

James F Fogarty, retired head of former North American Co, at the age of 72.

Homer W Forschner, general sales manager of Electric Machinery Mfg Company, on Oct 8. He was 54.

K M Irwin, vice-president in charge of engineering for Philadelphia Electric Company, on Oct 3 at the age of 67.

F C Kellogg, president of Pioneer Service & Engineering Co, on Sept 27.

Joseph N Kelman, founder of Kelman Electric and Manufacturing Co, pioneer in the power-circuit-breaker field, on Sept 24. He was 86.

Edward F Simon, founder and president of Ohio Machine & Boiler Co, on Sept 26 at the age of 81.

Maurice F Stack, former director and vice-president of Ebasco International Corp and Cuban Electric Co, at the age of 77.

Dr Harry K Ihrig

Allis-Chalmers Manufacturing Co vice-president Dr H K Ihrig died toward the end of last summer. In charge of research for Allis-Chalmers, Dr Ihrig made outstanding contributions in the research field. He held more than 20 patents in varying fields and authored numerous scientific papers. At Allis-Chalmers he headed the group of scientists which developed a fuel cell capable of powering an experimental tractor.

Dr Ihrig studied at the University of North Dakota and received his doctorate in chemistry from the University of California. He was research professor in biophysics at Marquette University's graduate school.

His affiliations included memberships in ACS, AIChE, AIME, ASM Electrochemical Society and National Society of Professional Engineers.

Consultants

Commonwealth Services, Inc: G O Ladd, senior consultant in the Rate Dept. **Dayco Corp:** R G Hayes, technical consultant on urethanes.

"I'm an 'expert' on AIR CONDITIONING"

What he means by air conditioning and what you mean by it are as far apart as the poles. He may be an "expert" but if you really want a full picture of the latest developments in air conditioning, you can do this best at the Heating & Air-Conditioning Exposition.

Top executives, salesmen and design and production engineers will be on hand to provide specific information and money-saving tips about use of related equipment, more efficient methods of installation, maintenance techniques and anything else they know from which you can profit.

More than 500 companies participating will constitute the most concentrated and versatile range of heating, refrigeration, air conditioning, and ventilating systems, equipment, and components available and applicable to your needs. *Plan your visit now!*

15th **International Heating & Air-Conditioning Exposition**

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CHICAGO, ILLINOIS
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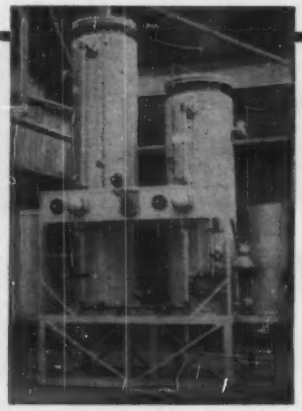

NEW FROM H&T
Low-Cost • High-Performance
"PACKAGE" DEMINERALIZERS!
TWO-BED and UN-A-BED
STANDARD UNITS
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Unless *special* conditions require you to use a *special* demineralizing system, you can save big money—and get excellent results—with the new H&T Standard "PACKAGE" DEMINERALIZER! Into these superior Standard Units, we've put the experience of 16 years in building many hundreds of manual and automatic demineralizing systems. *Result:* H&T "PACKAGE" DEMINERALIZERS are masterpieces of design and construction—unequalled in performance and wonderfully low in cost.

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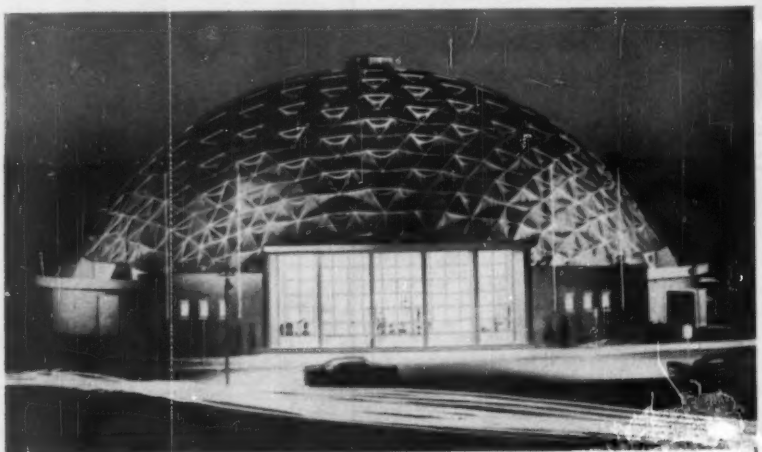

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Modern construction such as the Geodesic Dome of the Casa Manana Opera House, Fort Worth, Texas, requires the kind of lightweight moisture-barrier material only ASBESTON ALMF provides.

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Bookshelf

Ingenious Mathematical Problems and Methods. *By L A Graham. $1.45. Dover Publications, Inc, 180 Varick St, New York 14, N.Y.*

A new kind of "book" features original contributions by outstanding engineers and mathematicians. This collection of authentic mathematical problems was selected from the column appearing in the Graham *Dial*, organ of Graham Transmissions, Inc, of Menomonee Falls, Wis. For over 17 years they have printed scores of mathematical problems, many created especially for the *Dial* by its more than 25,000 readers.

In selecting 100 of the Dial's puzzles for publication in book form, L A Graham was guided by the assumption that "a vast group of people, when they put aside formal mathematics at graduation, retain nevertheless a latent love and interest in the subject . . . quickened and aroused by provocative problems of the sort we have to offer."

Following this line of reasoning, Graham chose problems which call for some knowledge of all branches of mathematics.

Some problems demand the application of more advanced math. However, most can be solved effectively by a number of methods. Evaluating the solutions offered by *Dial* readers, Graham points out that no solution is definitive—there is always room for more experimentation and improvement on the work that has already been done.

Unfired Pressure Vessels, The ASME Code Simplified. *By R Chuse, 154 pp, 66 tables, charts, $8.75. F W Dodge Corp, 119 W 40th St, New York, N. Y.*

Fourth edition of this simplified guide to ASME Boiler and Pressure Vessel Code, it's revised, updated, includes current changes of the Code. Text is clear and concise; author outlines and clarifies problems in shell thickness, material classification and identification and testing procedures, among others. Basic causes of accidents and failures, design pitfalls, steps for weld inspection are out-

at Wylie Filter Plant, North Texas Municipal Water Districts

. . . controlled by LimiTorque "Hi-Lo" Motorized Valve Operators

The water discharge of the North Texas Municipal Water Districts, Wylie Filter Plant, with a capacity of twenty million gallons a day, is controlled by "Hi-Lo" two speed LimiTorque Operators, mounted on Iowa Gate Valves.

The "Hi-Lo" LimiTorque Valve Operators are used in the filter gallery and high lift Pump Station of the Wylie Filter Plant, located at Wylie, Texas, and control the operation of the main pump motors. They help prevent water hammer and surge by opening the discharge valves slowly for the first 25% of valve opening and the remaining 75% at high speed.

North Texas Municipal Water Districts supplies ten North Texas Municipalities and the District's largest customer, the City of Dallas . . . Additional LimiTorque Operators are used in other pumping plants operated by the District.

Forrest and Cotton, Consulting Engineers for this project specified LimiTorque "Hi-Lo" Two Speed Valve Operators because of their extreme reliability and accuracy.

Solve your most complex motorized valve application by the use of "Hi-Lo" LimiTorque motorized operators for dependability, safety, operating economy and long service life.

LimiTorque can be field-mounted on your existing valves—contact your valve manufacturer or nearest LimiTorque sales-engineering office.

Send for complete new Catalog L-550, and please use your Business Letterhead.

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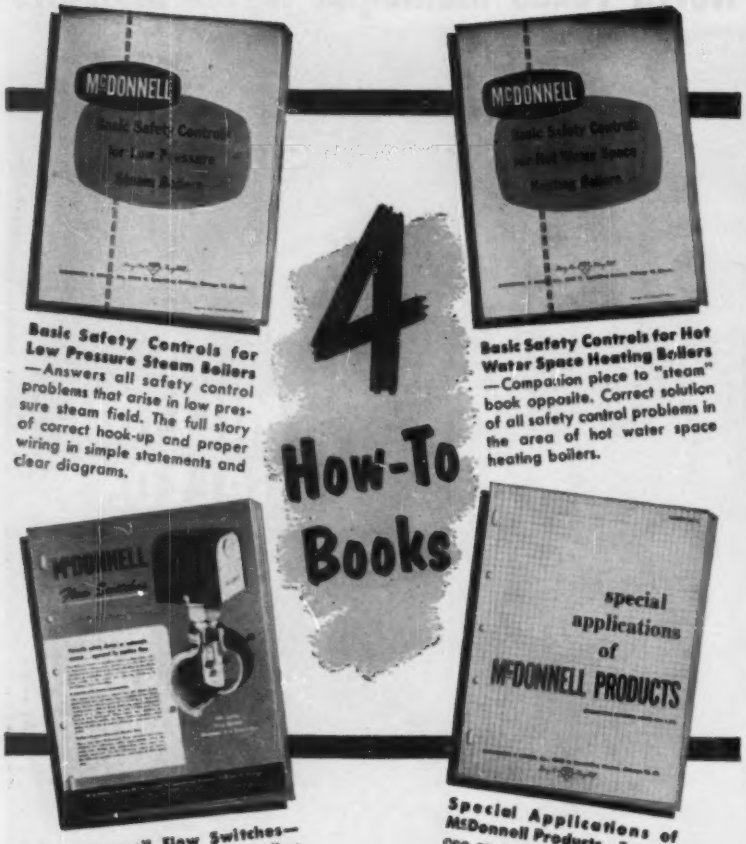

Basic Safety Controls for Low Pressure Steam Boilers—Answers all safety control problems that arise in low pressure steam field. The full story of correct hook-up and proper wiring in simple statements and clear diagrams.

Basic Safety Controls for Hot Water Space Heating Boilers—Companion piece to "steam" book opposite. Correct solution of all safety control problems in the area of hot water space heating boilers.

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Here are four bulletins that can make a basic contribution to the things every operating man seeks...more efficient operation... automatic operation...safer operation.

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Bookshelf

Begins on page 218

lined. Tables, charts and diagrams supplement text, help to give Code calculations quickly. This is a valuable handbook for those fabricating and using Code vessels.

Fuel Abstracts and Current Titles. *Published monthly by The Institute of Fuel, 18 Devonshire St, Portland Place, London, W. 1*
Monthly classified summary covers world literature on all scientific and technical aspects of fuel and fuel usage, takes over the job left by Dept of Scientific and Industrial Research publication which ceased publication in '58. This is a helpful reference for anyone doing research in fuel technology or concerned with the technical applications of fuel in industry. Annual subscription rate: $36.00.

The Johnsonville Steam Plant *(Technical Report No. 31). Tennessee Valley Authority. 678 pp, 264 illust, 90 exhibits (maps, diagrams, etc), $5.00. TVA Treasurer's Office, Knoxville, Tenn.*
Johnsonville, on Kentucky Lake in western Tennessee, is first of seven large steam-electric plants built by TVA between 1949 and '59. This report details planning, design, construction, initial operation and costs of Johnsonville's first six units; statistics cover the final four units.

The plant started with two units. Advent of the Korean War in 1950 made four more advisable, and normal system demands urged final 4-unit addition. Completed in 1959, the 1,350,000-kw installation has 10 units. This is one of the world's major steam plants. Johnsonville is a vital part of the TVA power system; its record should be of general interest to electric-power suppliers, engineers and constructors.

General Electric Co is producing sealed-off thermionic converters for industry. The size of a silver dollar, converter weighs three oz, generates at least 1-watt capacity.

Regenerating Water Softeners Efficiently:

Only one salt dissolver delivers fully saturated brine at lowest cost

It's the Sterling Lixator—a fully automatic rock salt dissolver developed exclusively by International Salt Company for making 100% saturated brine from economical Sterling Rock Salt. It's being used in hundreds of industrial and commercial water softener installations because of its simplicity, economy and trouble-free operation. Here are the Lixator's advantages:

Lixator has no moving parts—nothing to get out of order.

Downflow principle. After water is admitted into the Lixator, it flows *down* through the rock salt in the dissolving zone.

Brine is self-filtered for maximum purity. There is no sand or gravel filter bed to bother with. Instead, rock salt crystals in the lower portion of the Lixator completely filter the saturated brine.

Fully automatic. Whenever brine is drawn off, water is automatically admitted into the dissolving chamber to make more brine. Rock salt flows in from a Lixator hopper or down a chute from an overhead bin. The only requirement is to keep the storage section filled with Sterling Rock Salt.

Great flexibility. The Lixator can be placed anywhere, at a point most convenient for salt delivery. *Pipes* deliver brine to the softeners.

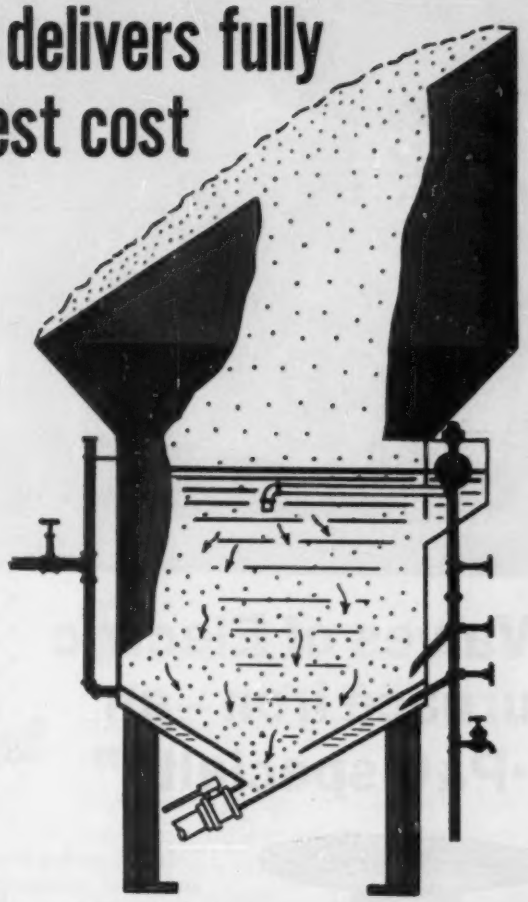
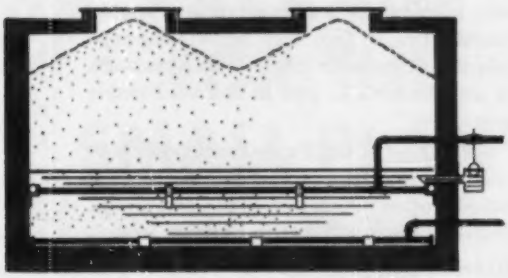


Diagram of Sterling Model Lixator. This is today's most widely used rock salt dissolver. It's available in many standard sizes—from 24" to 120" in diameter . . . with brine-making capacities up to 6,000 gallons per hour. Lixators come in enameled steel, Monel metal, or corrosion-proof plastic . . . with storage hoppers (standard low-lip, wall-type, cylindrical, corner, etc.) to suit any plant requirement.



▲ **Diagram of Sterling Storage Lixator.** Designed for larger operations, the Storage Lixator is a combination salt storage, salt dissolving, and brine storage tank. On delivery, Sterling Rock Salt is unloaded directly into the Lixator. Lixate Brine is made automatically, as it is in every type of Lixator.

For information on how your plant can save money with a Lixator, contact the nearest International Salt Company sales office. You can also get a free copy of "Brine for Today's Industry"—which fully describes the Lixate Process.

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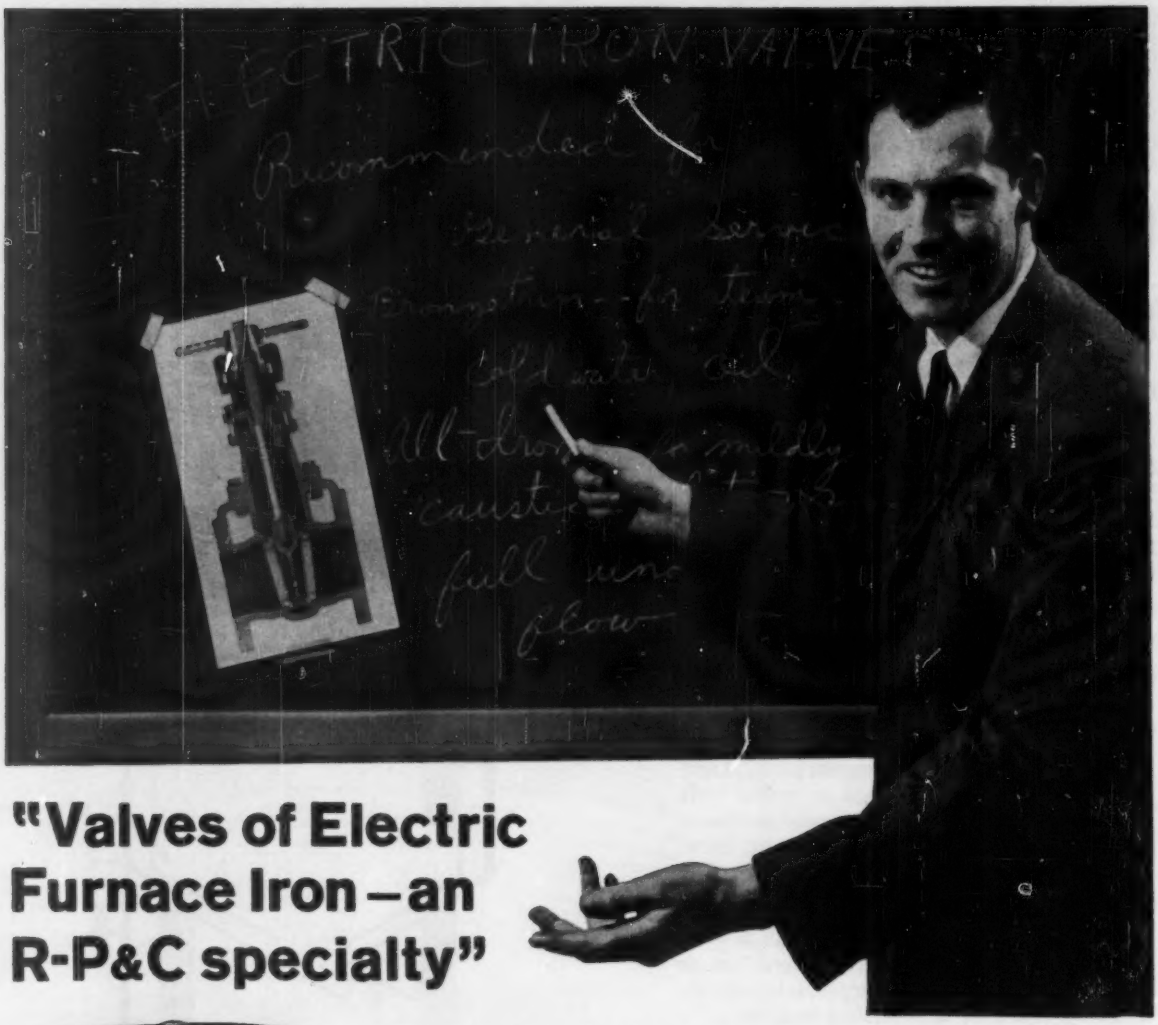

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"Manufacturing castings from iron melted in our own electric furnaces and to our own specifications has long been an R-P&C specialty. Recognized for their superior quality, these castings of **highly refined metal** are substantially free of impurities. Dense grain structure gives them a high resistance to corrosion, high tensile and transverse strength, plus excellent deflection characteristics. In fact, their **physical properties far exceed** the standard requirements for iron valve castings. And all of these advantages are available to you in R-P&C Electric Furnace Iron Valves at no extra cost."

Shown here is an R-P&C Gate Valve of the flanged end type. It is available in sizes from 2" to 24" in bronze trim or all-iron construction. The R-P&C Iron Valve line includes other popular types of Gate, Globe, Angle and Swing Check Valves—all made of Electric Furnace Iron.

Contact your R-P&C distributor. He can supply you promptly with any Iron Valve you need as well as gate, globe, angle and check valves in bronze, cast steel and forged steel; all in a wide range of sizes, styles and pressure classes. See him or write...

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ACCO

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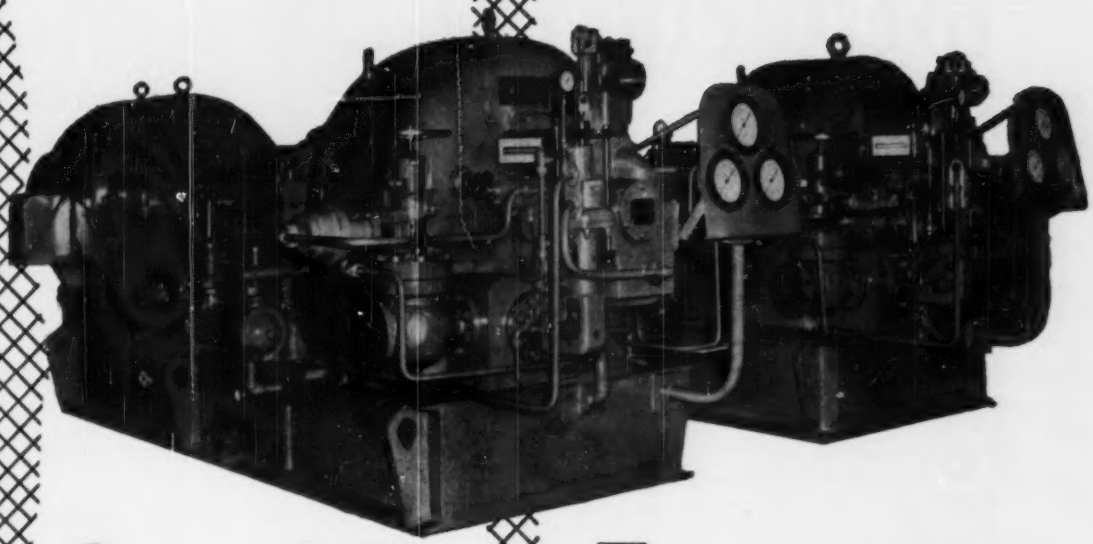

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This pair of 200 KW Murray Turbine generators supply constant, around-the-clock electrical power in a mid-western plant.

The Murray Design 75 — 400 KW Turbine generator sets provide all the safety and economy features of the most modern larger designs — and at the same time offer the advantage of low initial cost and maintenance.

Murray Turbine generator sets can also be furnished in ratings from 500 KW to 3,000 KW. Your Murray Representative will give you details. Write for his name today.

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Builders of Steam Power Equipment for Nearly a Century

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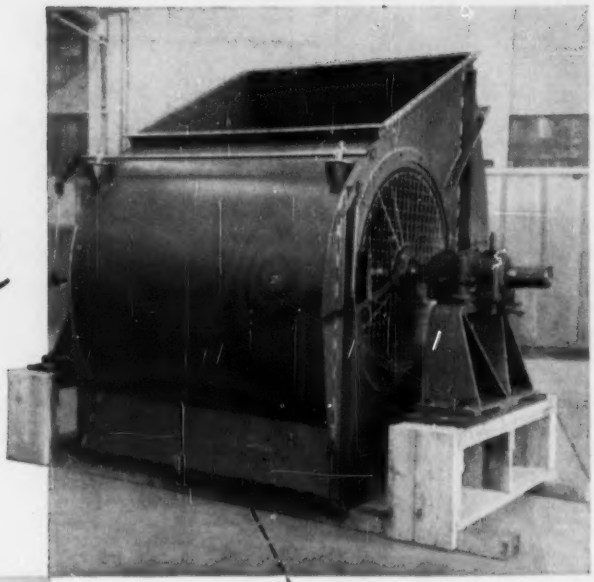
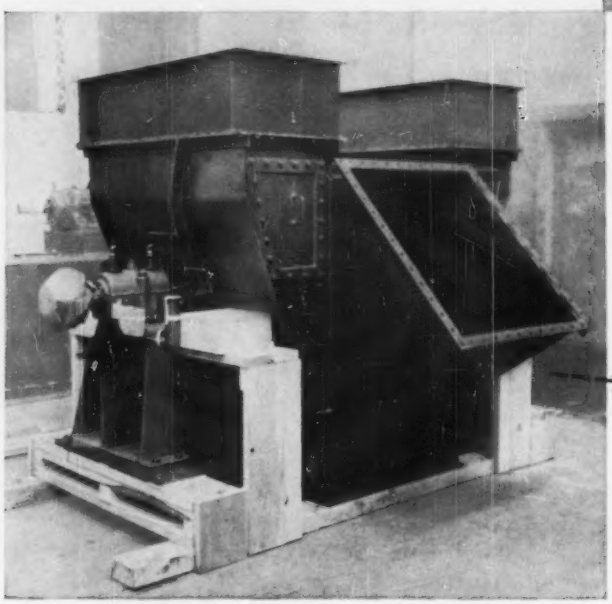
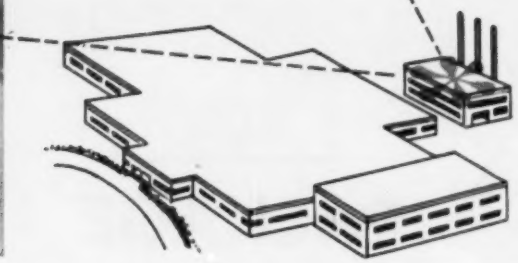
Headed for another tough job





...this mechanical draft "team" of top performers from CLARAGE



FOR FORCED DRAFT... FOR INDUCED DRAFT... AGAIN CLARAGE QUALITY IS THE CHOICE! These Clarage units, pictured on the shipping dock, will soon be in service at one of the nation's leading paper mills.

At the top is the Clarage Type AF Dynafoil forced draft fan with airfoil blades and Vortex Controls at the inlets; below is the Clarage Type DN Dynacurve induced draft fan with 36 forward curved blades. Clarage equipment, such as this combination, has been selected for over 4,500 central stations and industrial power plants. These users know that with anything as vital as uninterrupted operation, it pays big dividends to get the best in equipment—Clarage.

For complete information, request Catalog 905 on the Type DN, Catalog 859 on the Type AF, and Catalog 901 on the Type RT induced draft fan.

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For trouble-free underground hot pipe insulation specify GILSULATE® with Engineer-Supervised Installation

Every engineer charged with the responsibility of designing a central heating system to heat all buildings of a college, institution or industrial plant knows the money-saving advantages of such a system if properly planned. But he is aware that planning the underground piping can involve many problems, for the system must provide proper insulation and also protect pipes against corrosion, chemical and electrical attack.

The easy, one-step solution to many of the problems of underground hot pipe insulation is to call the GILSULATE distributor in your area: first, for the superior quality of the insulation material he sells and, secondly, for the excellent service he has to offer.

GILSULATE is a naturally-occurring mineral which, because of its unique chemical and physical properties, is chemically neutral in all soils, dielectric, impervious to mold, rodents and plant growth, and is water-resistant. Its thermal efficiency, low installation cost and long service life are supported by extensive laboratory and field research, and also by years of successful use in thousands of installations throughout the world.

Service that saves time and trouble—It is as important to our reputation that GILSULATE be used properly as it is for the engineer to assure his customer of an efficient, economical installation. Our distributors' experienced mechanical engineers will work with you in preparing underground piping plans, checking soil conditions and arranging for supervision of the installation work. And, without any cost to you, plans and specifications will be checked by American Gilsonite's Engineering Department.

Full-time engineer supervision of installations—Every GILSULATE installation of 30 tons or more is supervised by an American Gilsonite Company field service representative who stays on the job until it is completed. Smaller jobs are inspected by the distributor's engineer. This is a guarantee to everyone concerned...owner, architect, engineer, mechanical contractor and materials supplier...that every step of the job will be exactly to specifications.

Without obligation, we will be pleased to send you technical information on GILSULATE insulation so you can evaluate the merits of this low-cost, poured-in-place material. We will also put your name on the mailing list to receive free copies of PIPE INSULATION NEWS.

Once you have learned the merits of GILSULATE, we feel certain you will want to write your "specs" to assure the use of GILSULATE...*with engineer-supervised installation.*

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3. **Needs no housing or mechanical sheaths:** no mixing, special handling or equipment.
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5. **Four types available:**
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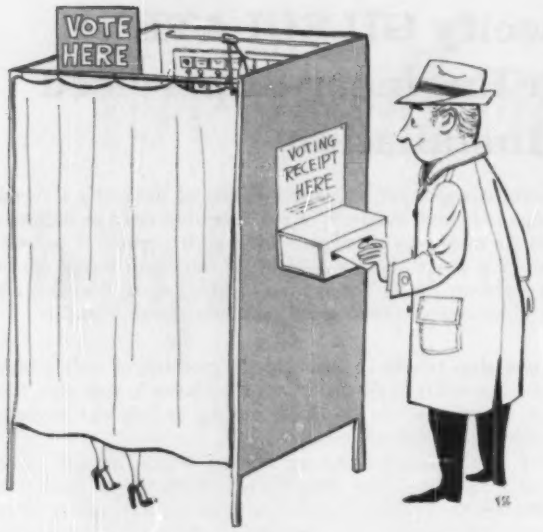


George Edwards

asks: Suppose nobody went "behind the curtain"?

A letter from Bob Caldwell in Pittsburgh, Pa. suggests an interesting wrinkle. Like a lot of us, Bob kept vigil into the wee hours last month trying to learn who would be the next President of the U.S. Nothing partisan about his note; no mention of whether or not his man made it. His first comment dealt with the Alice-in-Wonderlandy way we go about electing a president.

"We pride ourselves," he says, "on being the most progressive nation on the face of the earth. Yet we continue to stay with what a TV newscaster aptly called a 'constitutional monstrosity'." He goes on to say that it's our own fault, that we can throw the electoral-college system out if we want to. But enough people have to get riled enough to force the change, or things will stay as they are.

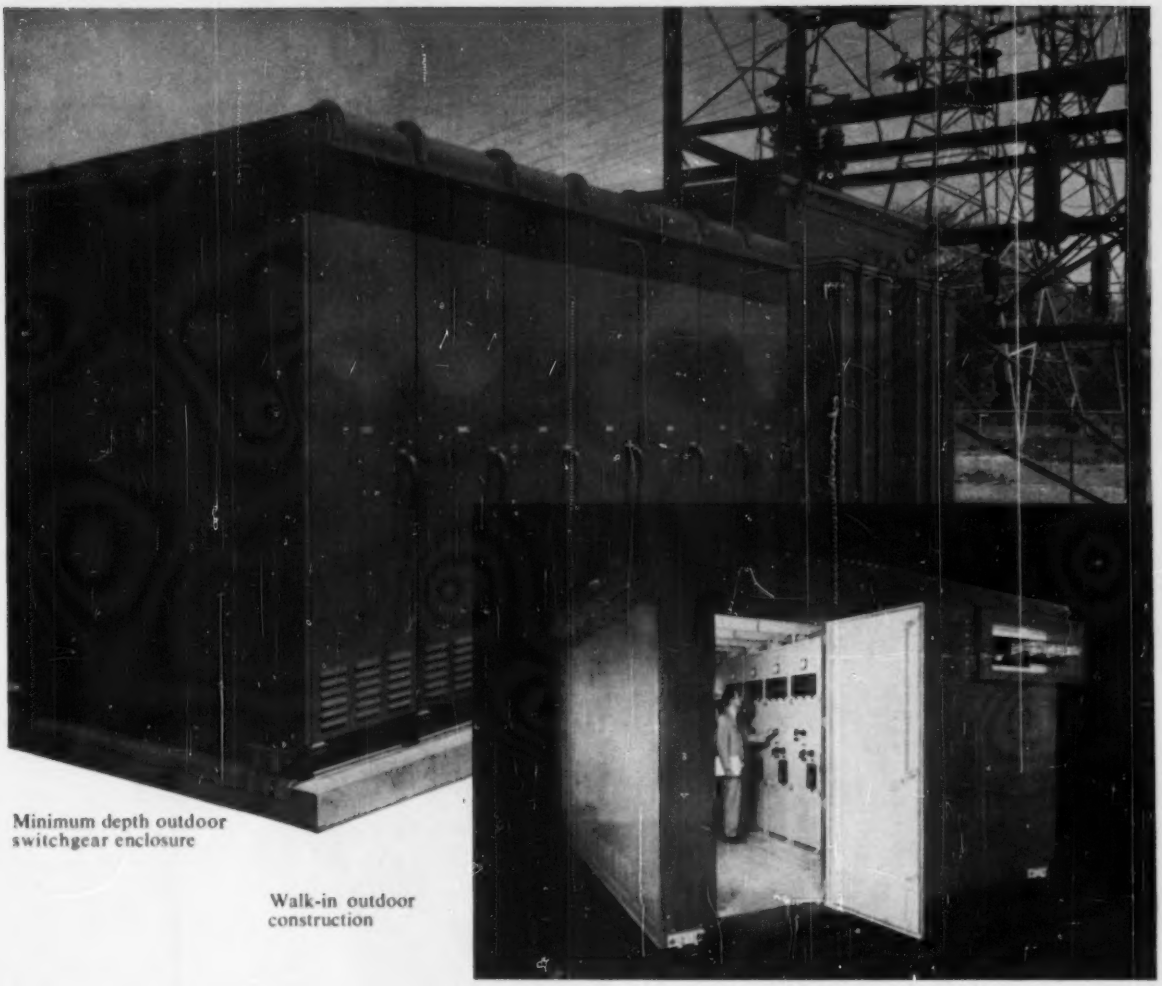
Next comes Bob's chief gripe, and his somewhat intriguing suggestion for corrective action. The fact that over 66-million voters turned out leaves him cold. "This country has over 80-million people qualified to vote," he claims. "So what happened to the rest? Let's assume that 30% of the no-shows had a legitimate reason. This still leaves almost 10 million who just can't be bothered. Appeals to their patriotism, such as your piece in POWER in November 1956 (*The most powerful man in the country*, p 174), mean well but don't do the trick. Maybe if these people got hit where it would hurt —in the pocketbook—we'd have a 'record' turnout at all local, state and federal elections."

Bob's suggestion is that each voter get a receipt as he leaves the polls. Nothing to indicate his party affiliation or how he voted, just to prove he showed. Come time to file his final income-tax return, he'd affix his receipt to the return with other proof of claims for legal exemptions. People who had legitimate reason for lacking a receipt could easily establish proof.

With passage of appropriate laws, Bob suggests, internal-revenue people could do a couple of things: (1) a return with no voting receipt—nor explanation of why not—would automatically cost the individual his $600 basic exemption (2)—which Bob says might be more effective because no additional legislation would be needed, and would knock in the head any screams about "constitutional rights"—such returns would go into a bin marked "full field investigation." Says Bob, ". . . since these people would be self-confessed shirkers of their moral obligation to vote, it's reasonable to suspect they might be ducking their share in paying for the free way of life we enjoy in this country. With a crackdown of this sort, Uncle Sam would uncover more than enough to pay for the extra effort."

Most of us will, I think, sympathize with Bob's thinking in this vein. But would this solution increase the quality of voting, or merely the quantity of votes—might it, in fact, dilute results desired by those who cast a *thoughtful* vote?

I'm sure all of us agree with Bob Caldwell's conclusion that it's unlikely we'll ever be able to do anything about the shirkers but, even so, our system is a million times better than living where one is *told* how to vote.



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Walk-in outdoor construction

All-new switchgear makes I-T-E primary unit substation better buy than ever

I-T-E custom designs your primary substation just for you—to meet your exact power, space and future expansion requirements—yet charges you nothing extra. This is just one of the ways that I-T-E gives you a better buy.

And now! I-T-E primary unit substations come with completely new HK switchgear as standard equipment. You get all the advantages of today's most advanced switchgear in outdoor equipment: new compactness, stored energy closing, new ease of access, and new safety for personnel. It's available in minimum depth outdoor enclosures for areas where space is limited, or outdoor walk-in construction for easy maintenance in bad weather. All doors and joints are completely gasketed. All parts are treated for rust resistance and painted prior to assembly.

I-T-E primary unit substations are available in all standard kva ratings and secondary voltages to 13.8 kv. Write for complete information. I-T-E Circuit Breaker Company, Dept. SW, 1900 Hamilton St., Phila. 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY

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Illustrated is one of the six 12-cylinder Fairbanks Morse Instant Power Units (Generating Model 38 TD8 ½) just installed at Thule, Greenland, key American defense base, to power the giant radar screens that warn of approaching missiles or aircraft.

This is the world's fastest-starting diesel generator—and the most economical

Advanced opposed-piston design—an exclusive Fairbanks Morse development—makes this Instant Power Unit the world's fastest, most economical standby!

Within 30 seconds, it hums to peak power! Full, vibration-less power! Automatically! Sturdy, self-contained, a complete generating package that delivers more kilowatts at less cost in less time than any other unit.

A model to meet every need. Automatic or manually controlled. Accessories to your specifications. For utilities and other vital services. Produces up to 2500 KW at 900 rpm. Can be linked in multiple units to supply any volume of power for peaking, standby duty, dead load pick up.

No faster, better protection at any price than a Fairbanks Morse Instant Power Unit.

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HYDROVANE DAVEY

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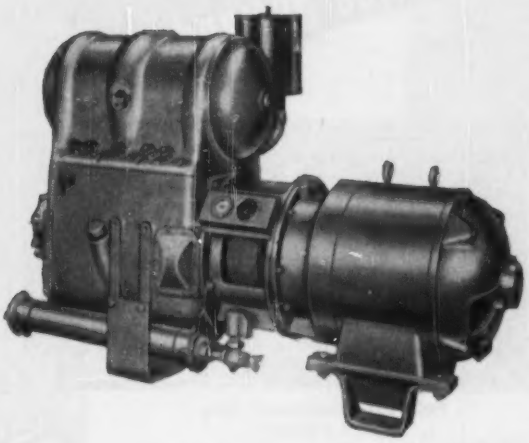
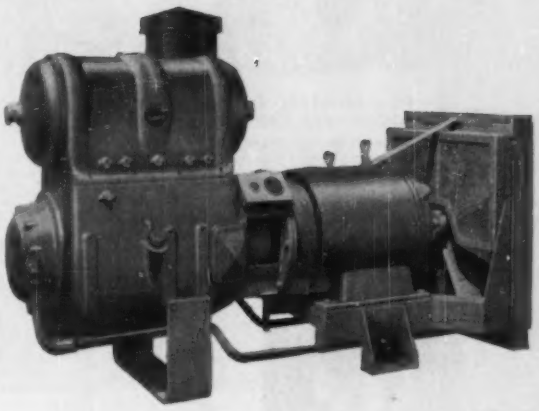


air-cooled



Davey stationary compressors are available in 2 to 125 h. p. @ 100 p.s.i. sizes

With Davey you can meet every compressor need—perfectly! For Davey gives you your choice of a complete line of both water-cooled and *air-cooled* Hydrovane Rotary units. These are equally efficient, economical to operate . . . built for long, trouble-free service.

This means you can now use air-cooled compressors in locations where water is not available or water cost savings are highly essential.

IMPORTANT: Oil consumption of Davey Hydrovanes is only a fraction (often less than 10%) of that of other rotary compressors. In fact, Davey Hydrovanes use no more oil than ordinary reciprocating units. *Also, only Davey offers long-life Perma-Vane* blades.* These eliminate blade deterioration and breakage—biggest source of rotary compressor trouble.

See your local Davey distributor today! Or, write for Bulletin E. A-2403A

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DAVEY pioneers of "air-cooled air"

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DAVEY COMPRESSOR CO.

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Distributors in All Principal Cities

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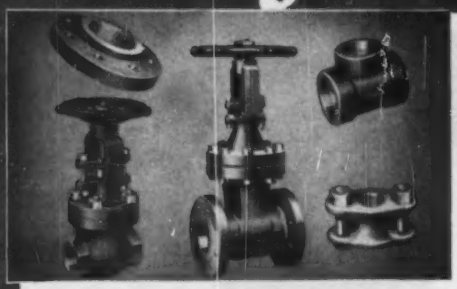

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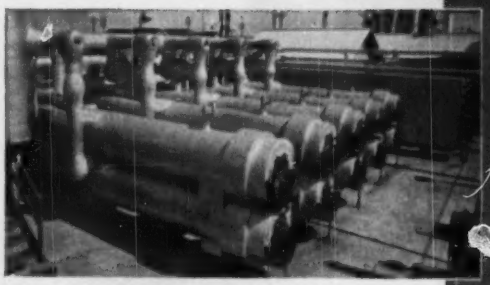

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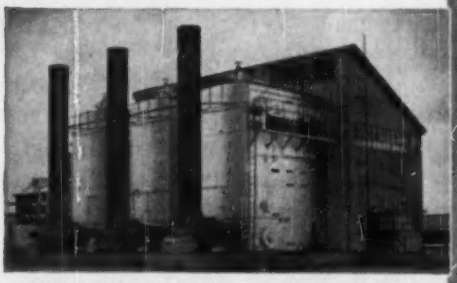

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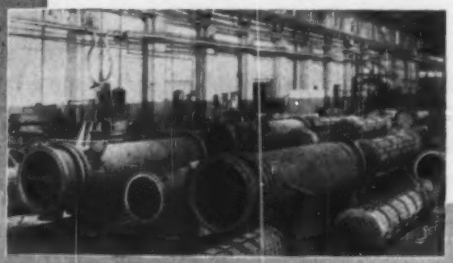

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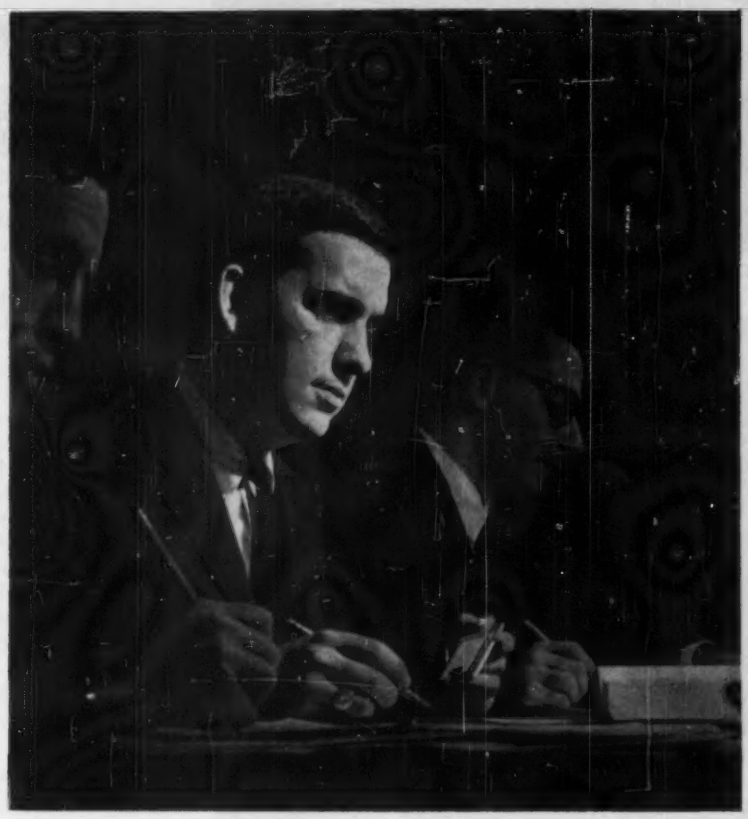


Here's how psychological testing can help you develop and at the same time aid top management in . . .

Spotting future engineer executives

By G BUCKNER II, Stevenson, Jordan & Harrison, Inc

Five years ago a combustion engineer in a large steel plant became discouraged, left to join a competitor. Today, he has reached top management responsibilities and operates a division of several hundred men—another example of an engineer treading water in one company and going on to win the freestyle in another. High technical turnover is not unusual, but it is unnecessary. The first company lost its investment in a technical man. And more important, it lost potential leadership.

Our engineer freely admitted he contributed only routine, uninspired performance in his original company. How can such a potentially dynamic administrator go unrecognized in one company and be spotted in another? The answer seems to be that company No. 2 had a formal program of tests combined with consultation, designed to ferret out and develop leadership.

Many companies and individual engineers distrust or fear this type of recognition and selection. So to clear away some of the mystery, here are straight answers on the usefulness, limitations and mechanics of testing programs designed to spot executive potential. To make the answers most useful to you as an engineer, the whole problem was examined from the dual viewpoint of an individual engineer about to be tested and management interested in starting a program for developing executive talent.

continued

EXECUTIVE REQUIREMENTS of company must be defined first. Psychologist and company management work out detailed review

TEST PROGRAM supplies basic information on each engineer. Level of knowledge, general aptitude and interests are defined

PERSONAL INTERVIEW by psychologist explores engineer's attitudes, permits detailed discussion not covered by basic tests

REVIEW OF REPORT by engineer and management helps define personality traits which should be encouraged or developed further

4-point program of testing.

As a management consultant dealing only generally with this problem, I went to Dr T A Jackson, head of The Psychological Services Div of our firm, Stevenson, Jordan & Harrison, Inc. Dr Jackson has initiated and administered hundreds of test programs for industry and based his answers to my questions on this experience. I asked seven questions which usually crop up from either management or individual engineers faced with a testing program. Here are Dr Jackson's answers:

What decisions must management make first?

First of all, management must decide what kind of consultant to use. I would specifically and emphatically stress the need to work with a qualified psychological management consultant. He must have a PhD in psychology, must be a Fellow in the American Psychological Association and should be a full-time practitioner in the industrial field. To get the cream of the crop there is one further requirement—he should be a "diplomate." This means he has achieved highest ranking among practitioners in the field. A directory of organizations and individuals offering psychological services to management can be had from the American Psychological Association, 1333 10th Street, NW, Washington 6, D.C. or from Dr Karl F Heiser, President, American Board for Psychological Services, Glendale, Ohio. It must be understood that not all qualified people are listed in this directory.

A company should pick a consultant it will be able and willing to work with from time to time. The same individual can help with selection as well as identification for promotion. Usually he will be able to help train and develop individuals, build a climate making the nonadministrative engineers more productive and creative.

Can test programs single out potential administrators?

I would not go so far as to say a test program will unmistakably identify administrators. It should be looked upon as a very valuable adjunct. The problem of identifying administrators is of such importance that the test program should be regarded as a supplement rather than the last word. I feel that engineers, even present administrative engineers, are inclined to want specific programs of action that will answer specific needs. It would be convenient if we could say tests are the complete answer, but that would be extravagant.

If greatest value is to be obtained from a test program, reports based on test results should be used as a stimulant to study each individual tested. A manager's observations of his subordinates (based on working relationships) should be combined with evaluation reports. This can be done best by periodic consultation between manager and psychologist. Their study of the individual not only

clarifies the man's leadership potential but provides the manager with a better general understanding of how best to develop him. Conferences of this type are valuable because they help the manager focus upon a study of his men, rather than wholly upon the nonpeople aspects of his job.

A test program combined with a continuing consultative study of the personnel will enable management to identify potential administrators much more effectively. If this kind of consultative study is carried on over a period of two to three years and combined with test results, highly accurate predictions of administrative talent can be made.

Can total programs be administered by company personnel?

No. Tests might be administered but they could not be interpreted by people in a personnel department. We, of course, have in mind companies of average size. Very large companies sometimes have a staff of professional psychologists in their personnel departments. We are not referring to these very large companies.

What portion of total programs are company administered?

As far as the testing program is concerned, part of this could be done by the company, although it is not necessary. It would also depend upon the size of the company. Obviously, company managers are involved in the periodic consultation program.

Can companies take advantage of evaluation programs to advertise that opportunity for advancement exists?

Let's consider present employees first. Initiating a testing program with present employees needs to be handled rather carefully. Many younger men have been tested so much in the Army and in the procedure of getting a job that they do not mind taking tests. On the other hand, older employees are somewhat apprehensive about tests, and a few may be positively distrusting. A test should not be forced and must be presented to them fairly. Usually you can say no one will be hurt by his test results and analysis may help him get ahead a little faster.

The whole testing program can be described as an elaborate way of getting a full description of the individual. When present employees are tested, they *must* be given the opportunity to talk over test results with the individual who reports to management. These feedback reports can help an individual manage his own abilities and talents more effectively. In addition, they serve to remove a good deal of apprehension about tests by dispelling what may otherwise be a mystery about the testing procedure. Rarely will you find an individual who objects to the testing procedure after he has had his own feedback interview.

I believe that over a period of years, employees become pleased to be a part of a company that goes to so much trouble to select its supervisors and managers. People resent selection for promotion on the basis of favoritism or merely seniority. Testing combined with other suggested procedures is objective and they invariably recognize this.

How is the first salvo of studies fitted into a continuing program which also picks up new employees?

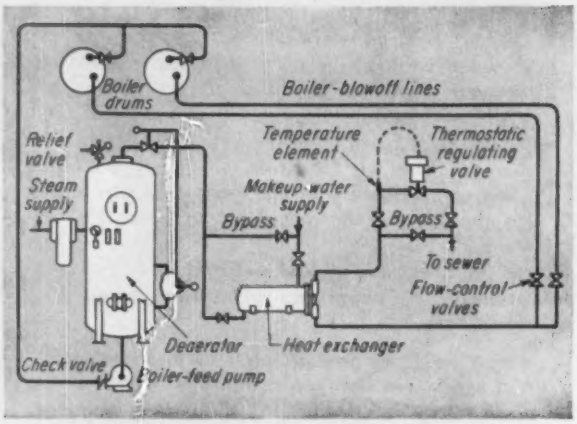
Once the testing program has been inaugurated and all candidates that may possibly be considered for administrative responsibility have been evaluated, then, of course, all incoming engineers should go through the same procedure. Procedure used may be essentially the same as might be used in the selection. Once test evaluation has been given, it is unnecessary to repeat until four to five years later. The consultation (review) program should be annual.

Do evaluation reports based on psychological tests always square with management's observations of a man's performance?

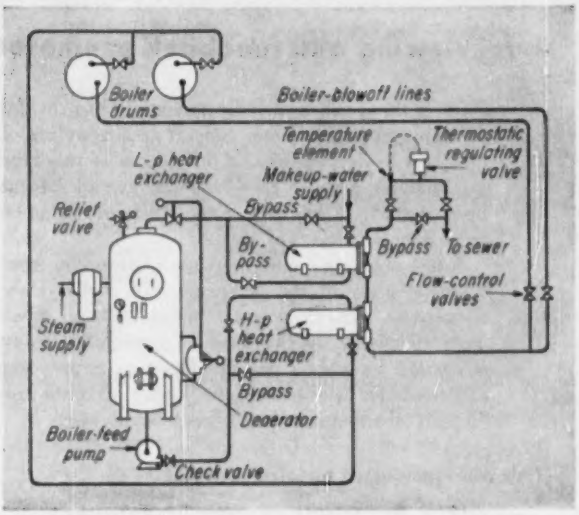
The answer to this question is "yes" 80 to 90% of the time. There may seem to be discrepancies, sometimes because the psychologist and manager use different language and do not observe precisely the same traits in an individual. If a case should arise where test results and a man's performance are at odds, we go into these situations much more thoroughly until the discrepancy is removed or accounted for. I would like to add that interpretation of test results can almost always be integrated with management observations. In fact, very frequently the interpretation of test results serves to confirm and crystallize supervisor's observations.

It is not a question of promotion by tests as contrasted with promotion by traditional methods. A test-evaluation program helps management mobilize and make effective use of their own powers of observation. It makes them more analytical of people. When management takes this kind of responsible attitude toward their people, both company and you as an individual profit.

While Dr Jackson's answers to these questions demonstrate the practical value and application of test programs, we emphasize once more that tests are not the "be all and end all" of successful selection and development of technical personnel. A test program without consultation limits effectiveness of the effort. In our experience, it is the *combination* — test programs and consultation— which packs the one-two punch for successful personnel operations for you or your company.



Simplest form of continuous-blowoff system is one in which water blown off from the boiler passes through a shell-and-tube heat exchanger to sewer. Makeup water enters the opposite side of the exchanger and picks up heat from the blowoff water. Rate of blowoff is controlled by a thermostat-actuated regulating valve located in the blowoff line leading to the sewer. Blowoff quantity is proportioned to makeup quantity, thus maintaining constant boiler-water concentration.



Small plants where blowoff amount doesn't justify flash tank can use this setup. Part of blowoff heat transfers directly to heated and deaerated feedwater. Remianing heat goes to makeup in second exchanger. This minimizes heat transfer to makeup without sacrificing thermal efficiency, is advantageous when adding heat to makeup might cut deaerator performance. This would occur if less steam condensed in deaerator, increasing quantity of steam relieved to the atmosphere by deaerator.

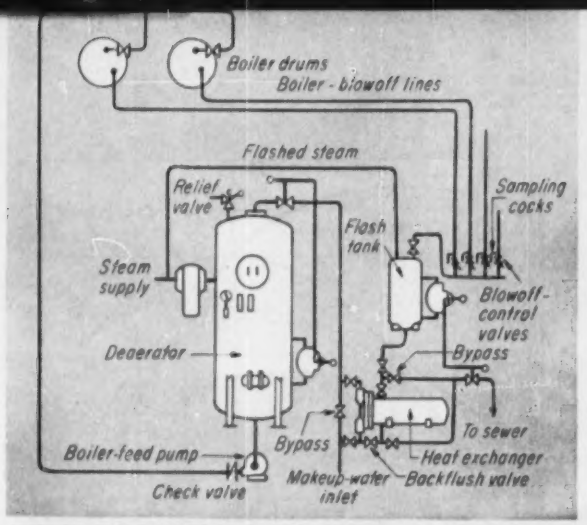
Last month we discussed continuous-blowdown principles and how to estimate possible heat savings. These typical hookups show how to . . .

Tailor boiler continuous-blowdown system to suit plant heat cycle

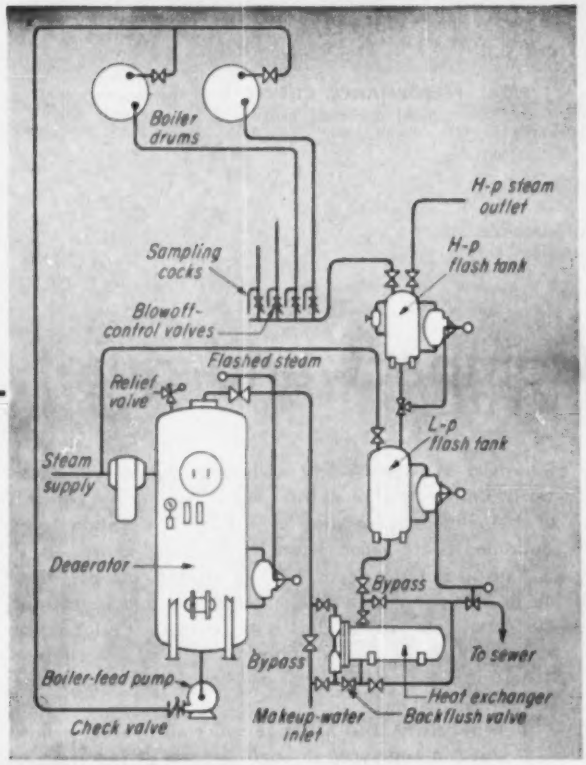
By HOWARD B FRANCE, Mgr
Deaerator & Steam Specialty Div, Cochrane Corp

No single continuous-blowdown system is applicable across the board. Arrangement choice is a matter of economics and where recovered heat can most effectively be used. Often, a combination of arrangements can be profitable. It's a matter of weighing equipment cost and simplicity against incremental savings. Example: Referring to last month's article we know that a 100-psi 25,000-lb-per-hr-capacity boiler with 2500-lb-per-hr blowdown can save about $655 a year using continuous blowoff with just a heat exchanger. Add a flash tank and savings are $670, not enough increase to justify tank cost even with water savings added. But a 600-psi boiler, same operating conditions, could save $210 plus 590,000-gal water per year, a good profit.

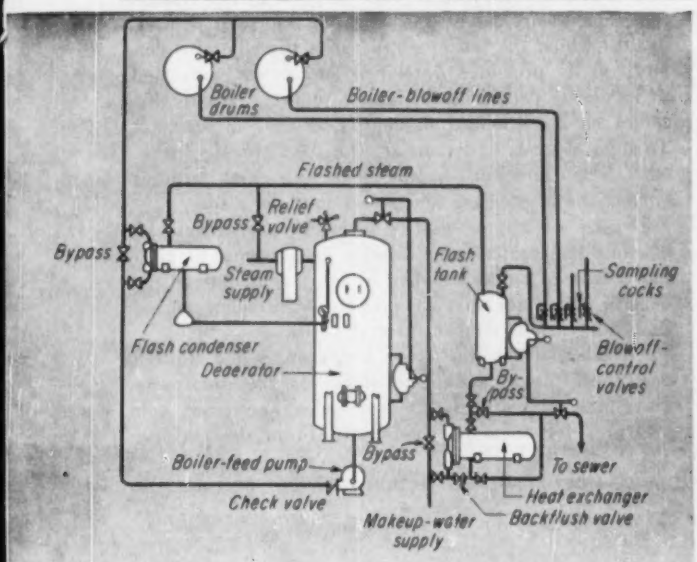
Systems become more profitable as boiler pressure, blowoff amount, heat value and operating hours increase. Here are some typical hookups.



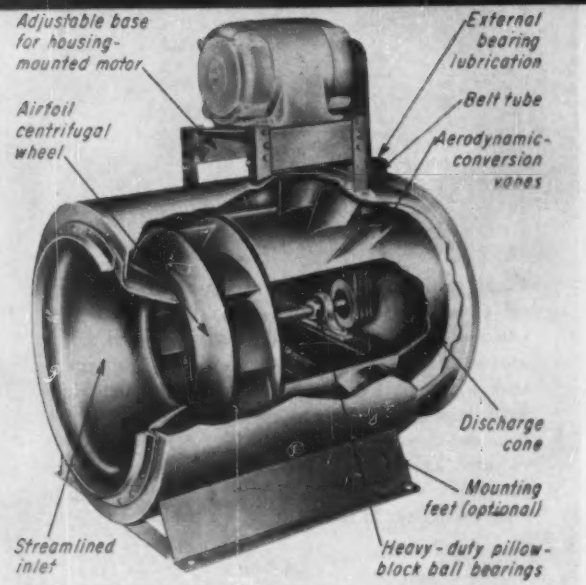
Flash tank should be used with a continuous-blowoff system if blowoff amount is large or if low-pressure steam can be used to advantage in deaerator or process. In this system boiler blowoff enters tank where part of water flashes into steam. Since most heat in the blowoff is in the flashed steam, heat exchanger's heat-transfer duty is significantly reduced. Effluent from the flash tank passes through exchanger where heat in unflashed portion goes to makeup, shown at left.



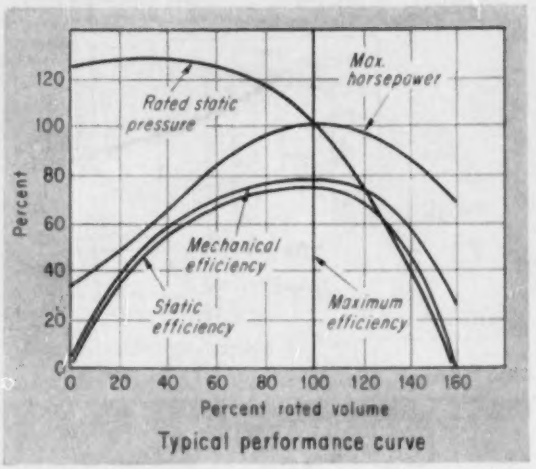
When high-pressure steam can be used to advantage, this arrangement gives benefits. Boiler-blowoff water is flashed at high pressure in one flash tank and the effluent water is flashed at a lower pressure in a second tank. Effluent from the second tank passes through a heat exchanger where remaining heat in the unflashed water is transferred to makeup. With this arrangement, quantity of low-pressure steam is minimized since much of the heat is recovered at higher pressure.



When low-pressure steam supply is sufficient for deaeration and process needs, this system can be used to advantage. Here, boiler-blowoff water is admitted to a flash tank where it flashes to steam at a higher pressure than deaerator pressure. This steam then condenses in a flash condenser by heating already preheated and deaerated feedwater. Condensate from flash condenser returns to deaerator. Flash-tank effluent goes through exchanger, gives up remaining heat to makeup.



CONSTRUCTION FEATURES show how aerodynamic-conversion vanes and airfoil centrifugal wheel combine for straight-line flow



TYPICAL PERFORMANCE CURVES have horsepower peaking within the normal operating range and at maximum efficiency

OPERATORS NOTEBOOK **144**

By STEVE ELONKA, Associate Editor

Compact and quiet:

By combining a centrifugal fan with conversion vanes for the first time, the Sturtevant Div of Westinghouse Electric Corp has developed a new straight-line-flow unit. Marrying these two features produces a fan with increased efficiency, less noise—and cuts down space needed. Now supply and exhaust systems can be tucked away in one-half the space needed in past.

This unit combines advantages of airfoil-bladed centrifugal-fan performance with space-saving features of straight-line air flow. It's expected to open up new design possibilities by fitting handily into small areas formerly considered "waste" space in commercial and industrial buildings. Fan itself may be as small as half the size of conventional scroll type units because housing is shaped for straight-through air flow rather than the conventional right-angle flow.

Exterior shape resembles an axial fan, but unit is definitely centrifugal. High efficiency comes mainly from the airfoil-bladed centrifugal wheel. This design lets air follow the blade contours closely, preventing noise-producing turbulence on upper blade surfaces. Aerodynamic-conversion vanes also minimize noise, an increasingly important element in personnel comfort.

Fan is rated by the same Air Moving and Conditioning Assn (AMCA) classifications as conventional scroll-shaped centrifugal fans. Airfoil wheels are from 27- to 44½-in. diameter, unobstructed design with no intermediate rings or stay rods to interfere with quiet streamline air flow. Heavy-steel all-welded casing is braced internally to carry weight of largest motors and allow for two methods of mounting: motor base on fan housing or motor mounted separately on integral vibration base. Both models are V-belt driven as illustrated above.

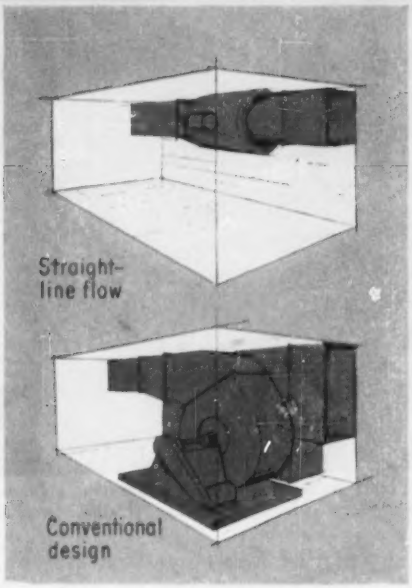
Volumes range from 4700 to 46,800 cfm, pressures up to nine in. of water static. Inlet and outlet sizes are the same—one size of duct may be used. Performance and sound levels closely duplicate those of the conventional scroll-shaped airfoil-bladed centrifugal fans of the same wheel diameter.

Temperature and altitude won't affect volume flow—flow at constant speed through one size of fan remains the same regardless of gas density. But total pressure against which the fan operates varies directly with density; so do pressures developed and power consumed.

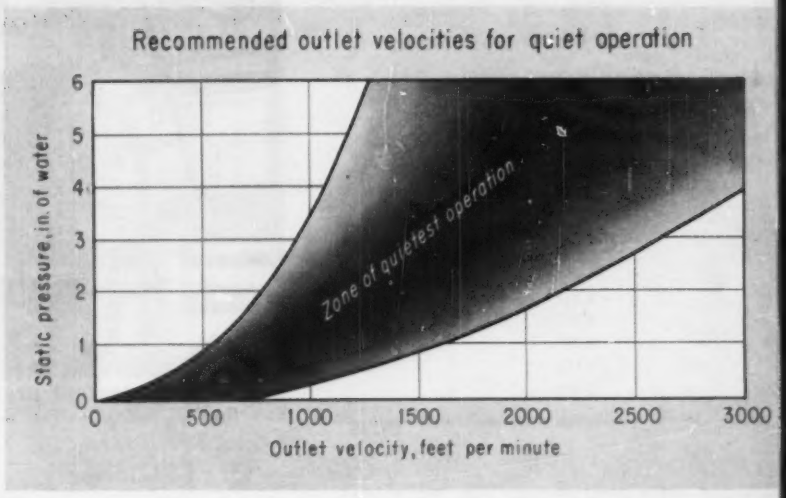
Standard performance tables, curves, friction-loss tables, etc use standard air density of 0.075 lb per cu ft. This corresponds to dry air at 70 F, 29.92-in.-Hg barometer. When fans must handle gases with other densities, corrections in pressure and power must be made.

Density of air or gas is inversely proportional to absolute temperature and directly proportional to absolute pressure. Tables supplied by fan manufacturers give density ratios for making proper performance corrections for various temperatures and altitudes.

To select a fan for other temperature and altitude conditions, figure system resistance in the usual way. Determine pressure requirement—also known as cold pressure—for standard conditions. From the perform-



COMPARISON of typical installations shows how new design, top sketch, can save space



ZONE OF QUIETEST OPERATION is indicated by darker shading through center of curve. But fans can't be considered really quiet at higher pressures

the straight-line-flow centrifugal fan

ance tables, select a fan for proper volume at the cold static pressure. Fan will produce the same volume at selected rpm regardless of density. Pressure actually developed is cold pressure multiplied by the density ratio. Brake horsepower listed in the performance table, multiplied by density ratio, gives you required hp.

A specific weight of gas is needed for some applications—examples are combustion air or drying. In this case, divide fan inlet volume at standard conditions by the density ratio to get volume desired at the elevated temperature or altitude. Calculate cold static pressure for the new fan inlet volume and proceed.

Fan selection boils down to a problem of balancing first cost and operating costs. First cost covers initial price of fan, motor, drive, accessories, ductwork, hoods, grills, insulation, plus the tally for installation. Operating costs include electrical power needed to run the fan, and system maintenance. Consider expected life of installation, quietness required, location of equipment, space available, etc.

Public buildings, hospitals and schools should get 20 years or more fan life. But some industrial jobs are less permanent—first cost can weigh heavy. If low operating costs are important, select fans near peak efficiency and size ductwork for low velocities and minimum resistance. If you're shooting for low first cost, select smaller fans well below maximum efficiency and size ductwork for maximum velocities. These fans will mean higher resistance loss and higher fan-horsepower needs, but they'll occupy minimum equipment space for the job.

When static pressures are high, fan size is smaller for a given volume and efficiency. Power requirements go up with the higher pressures, so fans can be evaluated at a high efficiency over a shorter period of time.

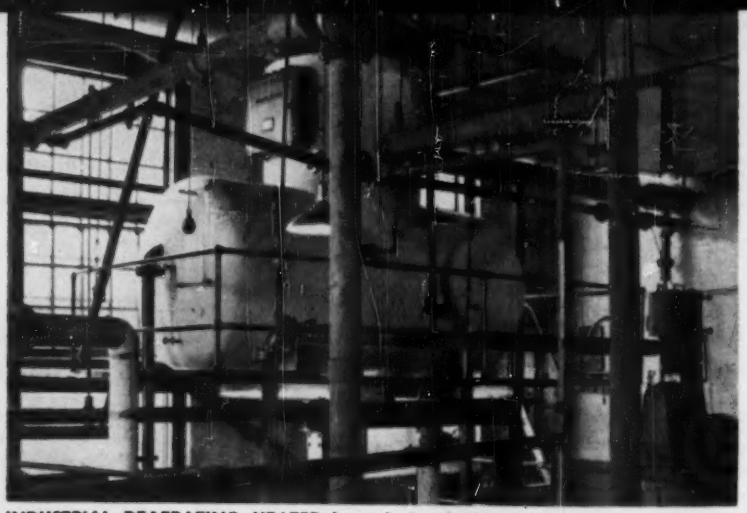
Noise for a given pressure depends on two quantities: fan speed and velocity of air leaving the wheel. Pressure developed by a fan depends on the product of these two quantities, and on whether the fan has low-speed forward-curved blades with high air velocity or higher-speed backward-inclined blades with low air velocity. Since noise is proportional to pressure developed, it's the same for either wheel at any given pressure.

Design of this airfoil-wheel fan lets the air follow the blade contours closely, eliminating noise-producing turbulence on the upper blade surfaces. Aerodynamic-conversion vanes direct the air flow leaving the wheel through the casing and discharge cone in straight lines.

In general, noise-level tests prove that fans are quietest when operating in the vicinity of maximum efficiency. Chart, above, indicates outlet velocities for the zone of quietest operation. Following this chart will help you select the quietest possible fan for the job.

Mechanical noise also must be considered. A solid foundation with proper vibration isolation is best for extreme quietness (see *Vibration Isolation*, POWER, Aug 1960). Bearing noise at normal fan speeds is insignificant for practical purposes. For normal maintenance, rolling-contact bearings are preferred to sliding-contact.

By A F McCORMACK, Manager
Puraq Water Softener Div
Commercial Chemical Products, Inc



INDUSTRIAL DEAERATING HEATER heats boiler feedwater to saturation conditions. This frees O_2 and CO_2 from the feedwater, reduces boiler-tube, pipeline corrosion

Industrial deaerators aren't easy to test so sometimes they're neglected. But O_2 and CO_2 removal is needed in almost every plant—the deaerator must do its job. Here are three simple ways to answer the question . . .

Is your DA heater sick?

Most equipment failures in industrial power plants are readily seen —a pump or compressor stops or boiler output falls off. But when deaerators fail to adequately remove O_2 and CO_2 from the feedwater, there may be no outward evidence until boiler-tube failures ring the alarm.

Continuous DA-heater testing for dissolved-gas removal by accepted methods is somewhat complicated, so performance checks tend to be neglected for long periods of time. You may not know that your deaerator is sick — or perhaps dead — until the damage is done. A recent check of many industrial DA heaters showed that an alarming number were not working—*and no one knew it.* Some showed evidence of not having done a good job for years. Here the original cost of the heater was money completely wasted, and boiler tubes were living on borrowed time.

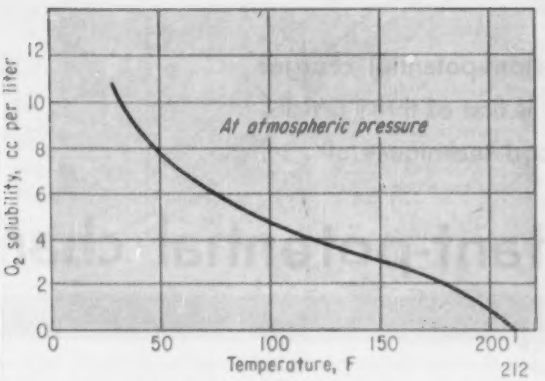
Just how does a DA heater remove dissolved O_2 and CO_2 from boiler feedwater? First, it heats the water right up to saturation temperature corresponding to operating heater pressure, table at right. Second, it breaks the feedwater into tiny droplets to expose maximum water surface for escape of dissolved gases. It may use sprays or cascade the feedwater down tiers of trays to do this, but in any case the end result should be the same—freeing O_2 and CO_2 and permitting them to pass off through a vent.

Any one of three simple tests will tell you if your DA heater is doing a job. They won't necessarily tell you how *well* it's performing; for this you will probably have to go to more sophisticated tests or perhaps call in a water consultant.

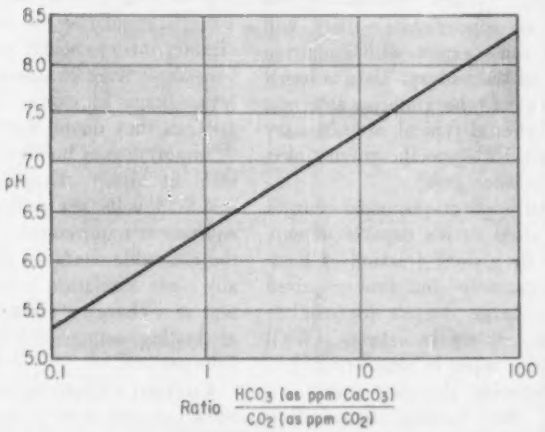
Temperature comparison may be the quickest and easiest way to check DA-heater operation. Steam and water temperature (t_1 and t_2, bottom drawing) should be within one to two deg of each other, indicating saturation conditions do actually exist in the heater and that O_2 and CO_2 can be separated out of the feedwater. And of course steam temperature will always equal saturation temperature at heater pressure (p_1) unless you have superheat.

Be sure thermometers are accurate —temperature difference you're looking for is very small. If possible they should be long-stem laboratory-grade thermometers recently calibrated. A good check: interchange them in the steam and water spaces and see if they still read the same.

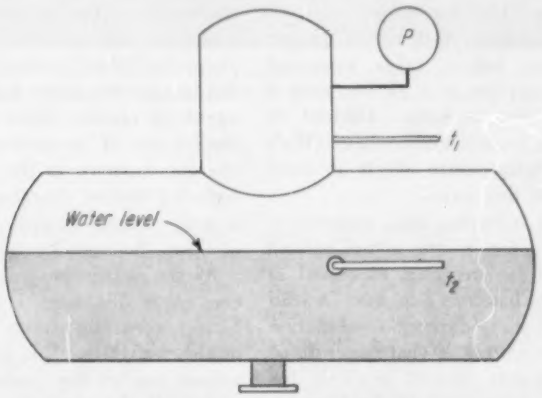
In some cases you may have a few deg of superheat in the inlet steam. Steam temperature will be slightly higher than that corresponding to saturation temperature at heater pressure, and there will be a slight difference between water and steam temperatures. This could mislead you unless you recognize the superheat. A good way to avoid the problem: get or make a special pressure gage for the steam-space reading, one whose dial rotates to read saturation temperature corresponding to heater



SOLUBILITY OF O_2 in boiler feedwater drops rapidly with increased temperature and reaches zero at 212 F and zero psig



pH OF DEAERATOR OUTPUT over 8.3 means ratio of HCO_3 to CO_2 is over 100 and deaerator is properly removing CO_2



COMPARING STEAM AND WATER temperatures—they should be together—is a check on proper deaerator operation

Saturation pressure-temperature at sea level

Heater pressure, psig	Saturation temperature, deg F
0	212.0
1	215.5
2	218.8
3	221.7
4	224.5
5	227.1
6	229.8
7	232.3
8	234.8
9	237.0
10	239.5

pressure. You'll have to adjust the dial to account for saturation temperature at the altitude of your plant.

Heater-output pH check is a good gage of operation, since a properly working DA heater brings free CO_2 very close to zero. In normal alkaline feedwater, 8.3 pH means that the HCO_3/CO_2 ratio is over 100. If pH stays above 8.3, no significant quantity of CO_2 can be present.

There are two easy pH checks. Your plant may already have a pH meter that you can use. If not, a few drops of phenolphthalein in a heater-output sample will tell the tale. If sample turns pink, pH is above 8.3 and your heater is OK. But if the test sample remains clear, residual CO_2 is forming carbonic acid (H_2CO_3), driving pH below 8.3.

Sulfite is used to scavenge boiler O_2 in most small industrial plants. Proper amount to keep in the boiler was probably set by a water consultant when the plant was new—in most cases about 30 to 50 ppm. To maintain this concentration, you normally add sulfite in the range of two to five lb of sulfite per million lb of steam. This makeup takes care of sulfite lost with the blowdown as well as the slight amount used to scavenge traces of O_2 in the boiler. But if all of a sudden it takes many times the prescribed sulfite to keep the correct boiler concentration, it may signal that your DA heater is not removing O_2—leaving it all up to the sulfite.

Here are more clues to faulty DA-heater operation. Watch for them:

(1) If steam pressure in the heater drops below zero psig, heater cannot be working right.

(2) Metal pitting in the heater storage tank or feedwater lines shows that dissolved O_2 and CO_2 are not being removed.

(3) A vibrating or rumbling DA heater is probably not doing a good deaerating job. Don't just stop the rumble, find out why!

Use these simple tests and watch for clues to faulty operation. Then you'll be sure your heater is doing the job for which you bought it.

How do you get most effective constant-potential charger for floated lead-acid batteries? This is first of three articles delving into not-too-widely understood techniques of . . .

Choosing constant-potential chargers

By EARL A HOXIE, The Electric Storage Battery Co

For years now we've realized the merits of constant-potential charging for floated lead-acid batteries—particularly for switchgear control. Without voltage control, constant supervision and frequent adjustments are the only way to keep performance and battery life satisfactory.

Silicon diodes and more-precise voltage-control methods have given us constant-potential rectifier chargers in a wide range of values. They may be adjusted to hold a constant voltage from no load to full load within ± 1% with ac supply voltage ± 10% from normal. Recent cost reductions make silicon competitive with selenium rectifiers; higher efficiency, compactness and freedom from aging effects make them attractive. Diverter-pole generators hold voltage practically constant over a wide range in load. They're turning in a satisfactory performance in many applications. But modern rectifier chargers with no moving parts and scarcely any noise are rapidly gaining in popularity.

A lead-acid storage battery may be completely charged without harm at a constant voltage within the range of the floating voltage, 2.15 or 2.17 to 2.35 volts per cell. But because of the exceptionally high currents taken at the start, it's seldom practical to provide sufficient charger capacity to charge throughout at a constant potential. Fig. 1 shows current taken by typical stationary batteries with lead-antimony grids when charged throughout from a discharged condition (100% of their 8-hr capacity) at voltages held constant at 2.15, 2.17, 2.22 and 2.33 volts per cell. Approximate starting current varies from 3.5 to 10 times the battery 8-hr rate in amperes over range of 2.15 to 2.33 volts per cell.

Consider values shown in the graphs as approximate — they will vary to some extent with condition and age of the battery. Data is based on a set of charging-characteristic curves believed typical of stationary cells with 1.210-specific-gravity electrolyte in each case.

In most applications, usual charger will be sized so it's capable of supplying only a small fraction of these starting currents—but time required for a recharge doesn't increase as much as you might expect. (We'll go into this topic in next article.)

In estimating charging curves it's assumed the battery temperature holds at 77 F. In actual practice, particularly charging at 2.33 volts per cell, there will be some temperature rise. The rise varies with cell size and design: with higher temperature the battery takes somewhat higher currents so a bit less time is needed for recharge. Current is lower at lower temperatures. (We'll discuss temperature effects in third article of this series.)

In the following data, *capacity of charger* refers to the actual current available for charging, expressed as percent of battery's 8-hr rate. A load on the battery-charger combination while the battery is charging will, of course, reduce current available for charging by amount of the load.

Floating voltage of 2.15 or 2.17 volts per cell must be held within close limits—perhaps ± 1%—since even a variation of ± 1% from these values affects stabilized current taken by the battery as much as 40 to 50%.

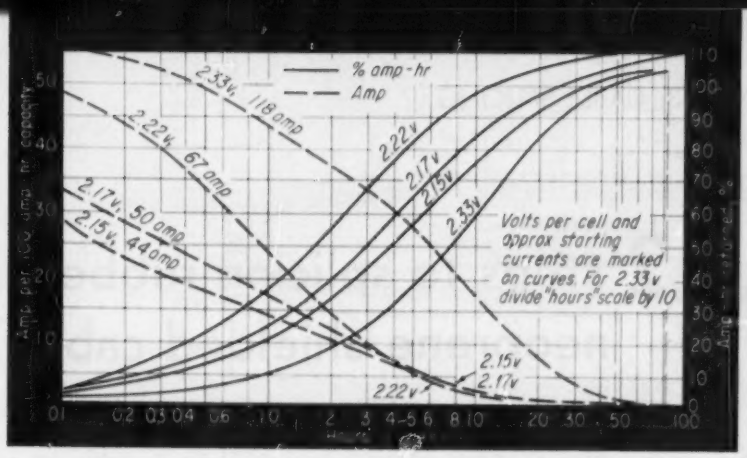
When constant-potential chargers are applied to batteries with no continuous loads, floating current is so small that charger load may be as low as 1 or 2% of full load. Close voltage regulation is therefore desirable, down to nearly no load. Some constant-voltage chargers won't regulate voltage as closely below about 10% as they do for larger loads.

Importance of holding voltage constant at higher charging voltages—say 2.33 volts per cell—depends on equipment requirements. These limit the allowable charging voltage. Usually close regulation is not as important at a charging voltage of 2.33 as at floating voltages of 2.15 or 2.17 volts per cell.

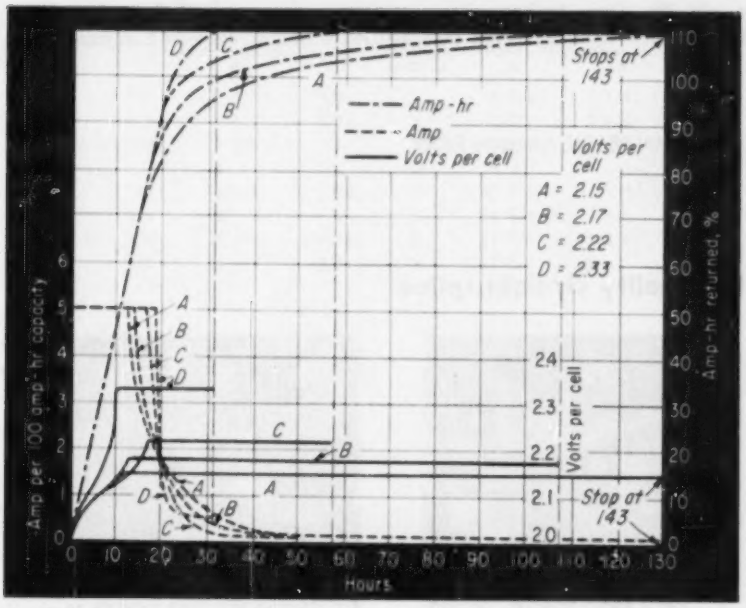
Current-limiting control can be combined with constant-voltage control where high starting currents and momentary or short-time loads on battery and charger would otherwise exceed the charger capacity. Charger voltage holds constant up to about the full-load rating in amperes. But at currents above full load, voltage drops rapidly, either transferring the balance of an external load over charger capacity to the battery, or reducing battery charging current to a value safely furnished from the charger. So capacity isn't exceeded.

As the charge progresses after an emergency discharge, voltage of the battery rises and charge current diminishes slightly. This goes on until voltage reaches the constant-potential setting of the charger and current drops to a value that can be furnished by the charger.

Percentage of rated full-load current at which charger's current-limiting control is effective varies to some extent with different chargers. So does rapidity of voltage decline with further increase in load. Let's consider, to make matters simple, that charger maintains a constant voltage



1 Constant-potential charge curves describe batteries with lead-antimony grids, specific gravity for the electrolyte of 1.210 at 77 F, discharged to 100% of 8-hr capacity



2 Typical charges from constant-voltage charger show a capacity of 40% of 8-hr rate. Lead-antimony batteries discharged 100% of 8-hr rate. Specific gravity here is 1.210

up to full rated load, then a constant current at voltages less than its constant-voltage setting. We'll assume a charge at constant current followed by a charge at constant potential in following illustrations.

Maximum charge voltage for switchgear-control batteries is determined by limitations of connected equipment. Usually it's 2.33 volts per cell, or 140 volts for a 60-cell nominally rated 125-volt battery.

Fig. 2 graphs typical charge of a battery with lead-antimony grids from a constant-potential charger. Graph starts at full-load current of the charger followed by constant potential at 2.15, 2.17, 2.22 and 2.33 volts per cell. Curves show a battery charge in terms of current per 100 amp-hr (or 12.5 amp for 8 hr) from a charger rated at 5 amp or 40% of the battery's 8-hr rate.

Time required for recharge after a discharge is usually the first consideration when planning charger capacity. This brings up the interesting question: When is a battery fully charged? Before you can determine charge time, it will be necessary to decide how many amp-hr need return to the battery to bring it to full charge—in other words, arrive at an amp-hr efficiency for entire charge.

Specific gravity of the top electrolyte, as read by a hydrometer, can't always be relied on to indicate true state of charge when charging at constant potentials, particularly at less than 2.3 volts per cell. Low current rates prevailing toward the end of the charge produce little gassing, so diffusion of the more-concentrated electrolyte made inside the plates during charge is not complete. However, at these low rates the amp-hr efficiency is higher than it is with higher charging rates—a greater percentage of the current is used in converting active materials and less current is wasted decomposing water.

Custom provides from 10 to 15% overcharge for batteries in daily cycle service, motive-power applications for instance. But really it's quite possible that not more than 5% amp-hr overcharge is required on a constant-potential charge to restore battery to full charge. This applies particularly to lead-antimony batteries with infrequent emergency discharges. Recent studies of lead-calcium batteries indicate that more overcharge (amp-hr above amp-hr of discharge) may be needed for complete recharge, especially if your battery discharges frequently.

Batteries in switchgear-control service don't discharge in appreciable amounts except in an emergency when regular power source fails. In these cases it's reasonable to assume that a charge equal to about 105% of discharged amp-hr will be adequate for lead-calcium batteries. If battery is not restored to complete 100% charge it will gradually attain full charge as it floats at normal float voltage.

Don't forget, we're using amp-hr and time required for recharge to mean a normal recharge, not requirements of an equalizing charge. Check manufacturer's instructions for information on equalizing charging of either lead-antimony or lead-calcium floated-duty batteries.

Next article will take up charging partially discharged batteries, effect of grid alloy on charging characteristics, charging lead-antimony batteries. Third article tackles charging lead-calcium batteries and effect of temperature on charge characteristics of batteries with both plate types.

Plant Electrical Fact File

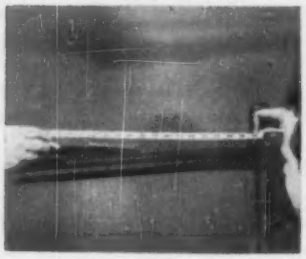
No. 53: CABLE SPLICING

12 steps to splicing rubber-neoprene shielded cable

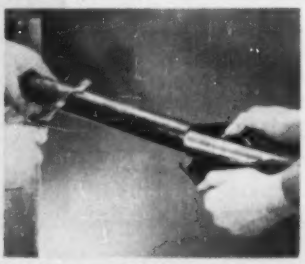
Splicing or terminating modern rubber-neoprene shielded cable isn't a difficult job—*if* you follow the correct procedure. Using splicing materials comparable with cable in composition and quality insures splice lasting for cable's life. Some typical cable constructions were described in *Fact File* No. 24, April 1958. *Prepared with assistance of The Okonite Company*

By NORMAN PEACH, Associate Editor

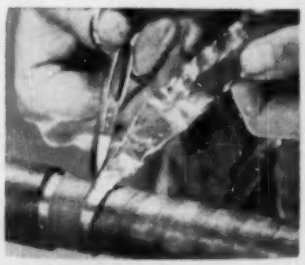
Follow these steps to get top-quality straight splice



1 Cut each cable at the midpoint between the support racks. This will let the conductors butt squarely together at the center of the splice. In this way you can avoid difficulties later on

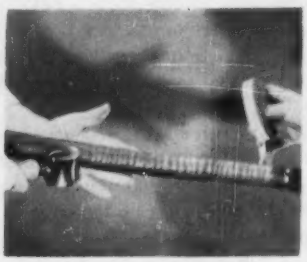


2 Cut and remove correct length of sheath from each cable end. Caution: avoid damaging cable's shielding. Be sure to hold knife so that in case it slips no damage will be done to cable

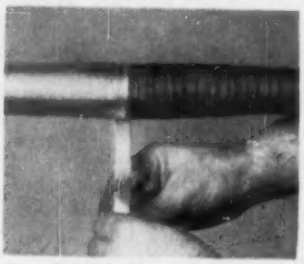


3 Remove shielding tape up to a point one inch from the end of the sheath. A few wraps of friction tape around the section of the shield to be preserved will serve as a guide when cutting

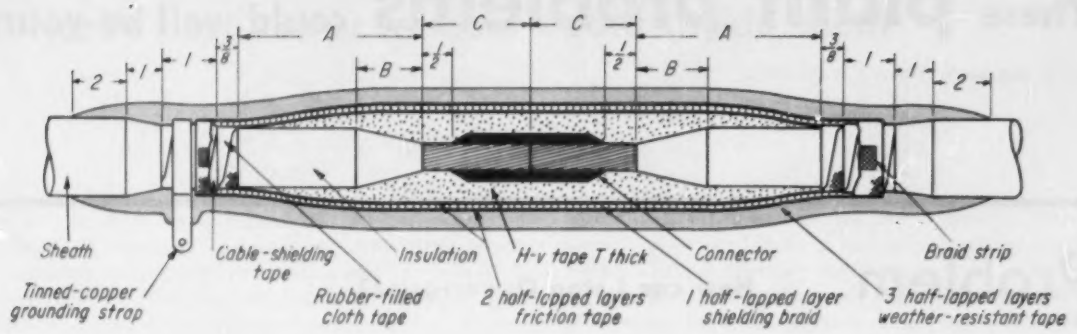
7 Apply thin film of rubber cement to surfaces. Use a putty-like insulating compound to fill indentations in the connector. Press compound into indentations so no air spaces are left unfilled



8 Apply insulating tape to splice half-lapped. Tension it to ¾ of its original width. Buildup should be about 1½ times cable's insulation thickness. Roll down each layer with a heated roller

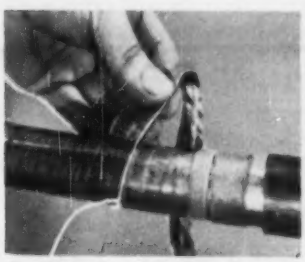


9 Wrap two half-lapped layers of friction tape over insulation buildup, then apply one half-lapped layer of copper shielding braid. Solder braid wrappings together by bead length of splice



You'll need correct dimensions for trouble-free splices

Insulation thickness, 64ths in.	Dimensions, in. A	B	T	Insulation thickness, 64ths in.	Dimensions, in. A	B	T	Insulation thickness, 64ths in.	Dimensions, in. A	B	T
10	3 1/8	1 1/4	1/4	26	8 1/8	3 1/4	5/8	42	13 1/8	5 1/4	1
12	3 3/4	1 1/2	5/16	28	8 3/4	3 1/2	11/16	44	13 3/4	5 1/2	1 1/16
14	4 3/8	1 3/4	3/8	30	9 3/8	3 3/4	3/4	46	14 3/8	5 3/4	1 1/8
16	5	2	3/8	32	10	4	3/4	48	15	6	1 1/8
18	5 5/8	2 1/4	7/16	34	10 5/8	4 1/4	13/16	50	15 5/8	6 1/4	1 3/16
20	6 1/4	2 1/2	1/2	36	11 1/4	4 1/2	7/8	52	16 1/4	6 1/2	1 1/4
22	6 7/8	2 3/4	9/16	38	11 7/8	4 3/4	15/16	54	16 7/8	6 3/4	1 5/16
24	7 1/2	3	9/16	40	12 1/2	5	15/16	56	17 1/2	7	1 5/16

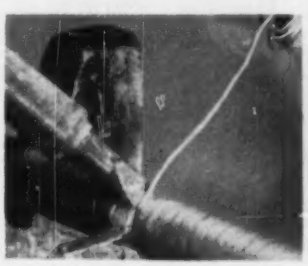


4 Remove bedding tapes covering insulation up to a point 3/8 in. from the end of the cable shielding tape. Here again a few wraps of friction tape will guide cutting, insure neat tape edge

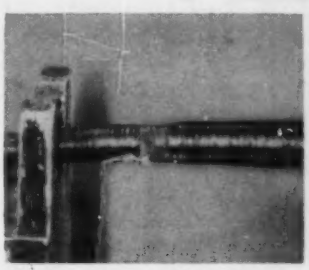
5 To prepare cable ends for the connector, ring-cut insulation at point half length of connector from cable end. If there's semiconducting tape remove it with insulation. *Don't nick strands*

6 Insert cable ends into connector, then "pencil" down sheath and insulation. Using nonconducting abrasive cloth, buff pencil and connector until smooth, then clean surfaces with solvent

10 Tack-solder a strip of tinned-copper braid along the entire length of the splice. Electrical contact should be established between the cable shielding tape at each end of cable



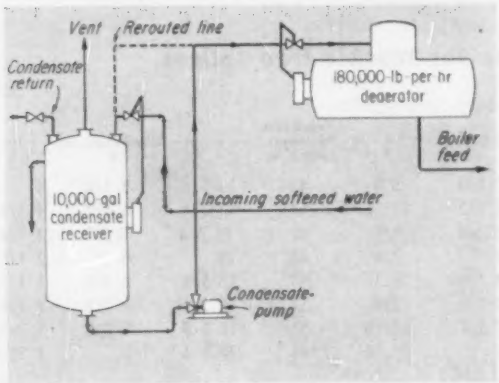
11 Shape a tinned-copper ground strap around the cable's exposed shielding tape and solder it securely in place. Then wrap two half-lapped layers of friction tape over copper shielding braid



12 Sheath the splice by wrapping it with three half-lapped layers of sheathing tape. Finally, connect ground strap to ground. Dimensions for the various components of splice are shown

These **plant problems** could well be yours...

Problem... How can I stop O_2 corrosion?



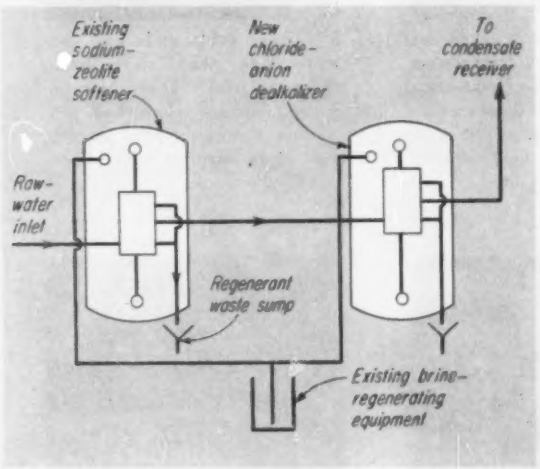
Our plant consists of three 60,000-lb boilers with a total-condensate-return system. Softened makeup water is now supplied to a condensate receiver controlled by a float valve as indicated. This provides a mixture of condensate and softened water which passes through the deaerator on its return to boilers.

Our condensate receiver has failed. Failure is a result of CO_2 and oxygen corrosion which is accelerated by the condensate-softened-water mixture.

It's my idea to introduce soft water just before entering the deaerator to limit the contact of the mixture to a short length of pipe, shown above.

I'm seeking engineering advice on the soundness of this change in operation.—*GRG, August* POWER

Solutions...



Install chloride-anion dealkalizer

Unfortunately, *GRG* has not provided an analysis of the condensate nor of the softened-water makeup. But I assume that dissolved oxygen in the condensate is low since boiler makeup water is deaerated. Corrosion undoubtedly is caused by CO_2 in the condensate. CO_2 is formed in the boiler by decomposition of bicarbonate alkalinity in the softened-water makeup. The following reactions explain chemistry involved:

(1) $2NaHCO_3$, sodium bicarbonate, in softened water + heat and concentration in boiler drum = Na_2CO_3, sodium carbonate, + H_2CO_3, carbonic acid.

(2) $Na_2CO_3 + H_2O$ + heat and concentration = $2NaOH$, caustic soda, + H_2CO_3.

(3) H_2CO_3, carbonic acid = CO_2, carbon dioxide + H_2O. CO_2 carries over with steam.

When steam is condensed, CO_2 is dissolved in the condensate, lowering the pH value and thereby promoting corrosion of the condensate receiver as well as the condensate-return lines. This problem may be eliminated by removing alkalinity from the softened-water makeup before it reaches the boiler. This, in turn, prevents formation of CO_2.

There are a number of methods *GRG* may use to remove alkalinity. Some of the most common are direct acid feed, hydrogen-zeolite softening with caustic neutralization and hydrogen-sodium zeolite blend. These methods, however, require means such as a forced-draft

...Here's how *Power* readers would tackle them

LAWSON STEWART, Associate Editor

decarbonator to remove most of the carbon dioxide released. Complexity of operation, space requirements, repumping and necessity of handling acid are some of the disadvantages. Simplest method—with none of these disadvantages—is the chloride-anion dealkalizer process.

Most economical method would depend on analysis of the raw water and amount of makeup required. However, since there are existing sodium-zeolite softeners and softened water makeup is less than 70 gpm, assuming that 90% of the condensate is returned and the boiler blowoff is no greater than 10%, the chloride-anion dealkalization process would appear preferable. This method would utilize existing sodium-zeolite equipment and only additional equipment required would be similar in size, appearance and operation.

Only difference between chloride-anion dealkalization and sodium-zeolite softening: exchange material (zeolite) exchanges anions such as bicarbonate alkalinity instead of cations such as hardness. A chloride-anion dealkalizer follows the sodium-zeolite softener in series and is regenerated with salt brine in the same way. This is shown on my flow diagram.

If the unheated softened-water makeup contains a large amount of free carbon dioxide in addition to bicarbonate alkalinity, it may be advisable to add a small amount of caustic soda along with the salt brine used to regenerate the chloride-anion dealkalizer. This permits the dealkalizer to also remove free carbon dioxide, insuring that none gets into the condensate.

W H ZAHN, *Philadelphia, Pa.*

Let filming amines do the job

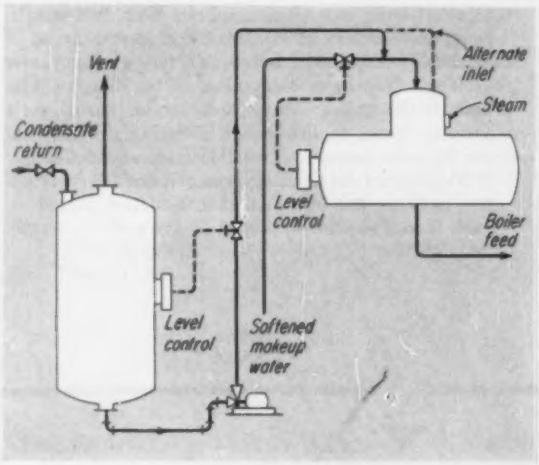
First, there is nothing wrong with introducing soft-water makeup either directly into the deaerator or with the return condensate. We have been doing just that at one of our power plants for over 30 years without ill effect. But this is not the least of *GRG*'s problem. How about chemical treatment and pH control on the condensate and feedwater system? This is all-important for a trouble-free system.

There are several good filming amines on the market that do an excellent job of holding down corrosion in a condensate system. They are inexpensive, considering the job they do. Amine can be injected into the feedpump suction by means of a small pump and tank. If *GRG* is using a sulfide in his boilers to scavenge oxygen, the amine may be added with the sulfide and the expense of a pump won't be necessary.

Condensate pH should be maintained at least between 8.8 and 9.0. We've used filming amines for years and have had no corrosion problems. At one plant we have a makeup requirement of 140,000 lb per hour. Amine requirement runs between 9 and 14 pints per day. In our newest plant which went on the line in January 1955 we use only evaporated makeup, and here the amine requirement is 1500 milliliters per day.

I am sure that with good chemical control *GRG*'s problem can be solved. There is nothing more destructive than a neutral condensate. So pH control is important—it will pay off in less maintenance and replacement.

J A FULLER, *Riverside, Calif.*



Here is a simpler setup

GRG's approach to the problem is a step in the right direction. However, not the best solution. My sketch is essentially a simpler system and is widely used.

Condensate should come back to your deaerating heater uncontrolled, with only enough softened makeup wate used to balance a deficiency in requirement. Condensate usually returns in slugs, hence the condensate receiver to smooth out the flow. Level controller should be on the discharge line from the condensate pump and then go directly to the deaerator.

If condensate temperature is within 30 deg of the steam temperature at the operating pressure on the DA heater, condensate should go through a separate line into the steam space in the primary stage of the deaerating heater. If it is cooler than 30 deg below steam temperature it can be added to the first stage of the deaerating heater through the line that adds softened makeup water, but after the control valve operating from the DA heater's storage tank.

I B REMSEN JR, *Pittsburgh, Pa.*

Want some help on plant problems? Send your design or operating headaches in for *Power* reader comment

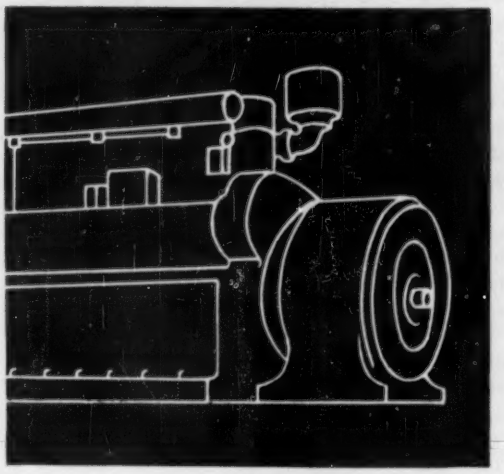
Problem...

Can we quiet our diesel?

We are thinking about installing an air-cooled diesel standby-power unit in a hospital. When we investigated similar installations we found that because of local and building design we would face a serious noise problem. Noise was comparable to an idling twin-jet aircraft. This unit, coming into service during early morning hours, could create a disturbance if not hazard for some patients if installed in or near buildings.

What would be the best type of building construction to house this unit and what insulation should we use? If we know the pitch of the sound can it be totally cancelled out by some practical method?

—*RSB, August* POWER



Solutions...

Quiet diesel plants call for soundproofing at inlet and exhaust

RSB's idling twin-jet sound probably came from a diesel with inadequate soundproofing of air inlet. I assume he is talking about a rather high-pitched whine. This is only one of the possible sources of engine noise.

To help him soundproof his new diesel we really must start with the bare engine and build up. First, engine design can have a lot to do with noise level. The noise level increases along with engine speed. This is a design characteristic and out of your control if you buy a packaged diesel motor-generator set. If, however, the two units are mated at the plant, speed ratios may be selected to keep diesel speed down. Air inlet emits high-pitched noise on most units. As a matter of fact, the engine blower and air box contribute more noise than any other single source in a modern diesel. Some of the newer designs have air inlets and blowers modified to reduce noise. *RSB* should check data on available units to see which ones have been redesigned. Other engine sources of noise are minor compared to air intake.

Engine mounting makes a big difference in noise transmission. If *RSB* can't install his diesel in a separate building, mounting becomes even more important. Engine foundation must contain enough mass to absorb most mechanical vibration or this vibration will show up somewhere else—as noise. At the same time, isolating the foundation mass with cork sheet, lead sheet, etc further prevents noise transmission.

Engine-exhaust silencers can be purchased from many sources. Engine manufacturers often will be willing to recommend several brands in specific sizes as best for a particular unit. These silencers can be mounted directly above the engine, with sections of flexible metal

duct connecting to the stacks. Checking with the engine manufacturer will automatically answer *RSB*'s question about sound frequency.

Air-intake snubbers tackle the same task for the blower-inlet noise. These snubbers are standardized in design. They're another item the engine manufacturer may be asked to recommend.

Piping, conduit and all connections to engine or generator should have flexible sections added to prevent sound propagation. This is a very important item.

Building construction depends upon location. If the engine must be installed within the main hospital building, heavy walls will merely lower sound level, not stop vibration and resulting sound completely. Best bet would be a separate building with heavy masonry walls and ceiling. There is absolutely no substitute for thick concrete or brick walls as sound absorbers. Most important of all, don't scrimp on original soundproofing. It costs a lot to modify later.

H KING, *Jackson Heights, N. Y.*

Install unit in separate building

Had occasion to visit a diesel auxiliary operation in Knox County that has qualifications for consideration by your reader with his institutional problem. Present diesel drives a 100-kw 250-v dc generator and is installed in a concrete building attached to the powerhouse wall opposite the institution. It's approximately 10x15 ft in size with 9-ft ceiling formed by precast concrete, interlocking slabs. The power unit is based on a concrete pier resting on bedrock 6-ft below grade line.

Exhaust is taken off by a flexible 4-in.-ID pipe with the muffler directly overhead on the roof. Muffler is 30-gal size. To keep noise well above the occupancy level the insulated steel stack is extended up the wall of the main powerhouse to a point 2-ft above the second-floor roof. Insulation eliminates resonance.

In process of installation is a 125-kw-ac 4-wire 208-v unit. To reduce exhaust noise on the outside where it can be objectionable with windows open in summer, new muffler is mounted under the ceiling in horizontal position with flexible line to manifold, and 6-in.-ID steel pipe extending up the powerhouse wall.

Powerhouse is some 80-ft removed from the institution, connected by a concrete tunnel. They get no complaints whatever about diesel exhaust. They're a little anxious about flue-blowing operations, but modern equipment now being installed will cure that.

W AMMONS, *Clinton, Tenn.*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches →

Your December problems

What power supply for cranes?

Our two 5-ton traveling cranes are due for thorough overhaul. Motors operate on 230-v dc supplied by m-g sets. Dynamic braking is provided for lowering. M-g sets are old and probably need rewinding since insulation is brittle. We have been considering replacing them with silicon rectifiers. What has been readers' experience with silicon rectifiers for crane duty? We installed them on a freight elevator about a year ago and performance has been good.

Can silicon rectifiers be paralleled with m-g sets for this kind of duty? Motors of our m-g sets are supplied with 440-v 3-phase ac. But actual terminal voltage is closer to 450. Nominal 220 v is available but voltage on our ac system tends to be a little above that. Will this cause rectifier difficulties?—*REH*

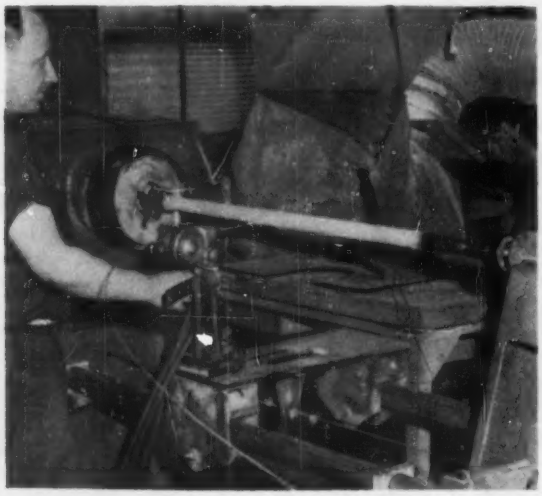
How do I stop soot, ash damage?

We have two watertube boilers of 30,000 and 40,000 lb-per-hr capacity respectively supplying steam for our dyeing and finishing plant. We fire Bunker-C fuel oil containing about 4% sulfur.

Our problem centers around soot-blowing operations for the two boilers. During each soot-blowing cycle, ash and soot from our stack filter back through plant windows and doors, causing great damage to material in production or storage.

We regulate our air-fuel ratio to supply about 18% excess air during normal operation, resulting in perfectly clean stack conditions. Plant construction would make sealing doors and windows prohibitive. Could POWER readers suggest a simple solution to our soot problem?—*DR*

Timely **practical ideas** to help solve



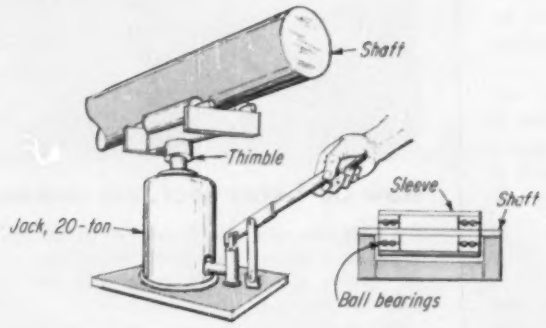
Here's how we protect our pump shafts against HCl

We metal spray our new and worn pump shafts with Hastelloy alloys B and C for longer service life in hydrochloric and sulfuric acids, ammonia, chlorine, other corrosives.

First we grit blast or machine prepare the base-metal area to be sprayed, then heat to about 200 F to eliminate any condensate. Part is built up with the required alloy by spraying. The alloy comes in ⅛-in. diameter wire and is applied with our conventional metal spray gun.

We spray not only the pump rod, but also all parts that are exposed to the acids: packing glands, bearing sections of shafts, hubs of impellers, and the linings of new pump casings. These alloys are melted in our metal spray guns with an oxyacetylene flame. Air converges where the wire melts and atomizes the alloy. The alloy, in a semi-plastic state, strikes the workpiece under an average air pressure of 65 psi. There is no fusion after spraying. Metals are bonded mechanically. Thickness of sprayed metal depends on buildup needed. At times this is as much as 0.040 in.

—Courtesy, Dix Engineering Co, Lincoln Park, Mich.



This roller jig removes heavy bearings

We had a lot of trouble removing bearing halves that were supporting a lot of weight. Rear main bearing of large diesel engines is one example. Our problem was being able to rotate the shaft, and support it at the same time. The answer was a homemade roller jig we designed, sketch.

We machined two sleeves and bored them at each end for press fitting the outer race of the roller bearings and two shafts to fit inner races.

Framework holding the jig together was welded out of heavy flat iron. The thimble is a piece of pipe that just happened to fit the stem of our jack which is a 20-ton heavyweight.

C A BELSHE, *Colby, Kansas*

Please don't write...

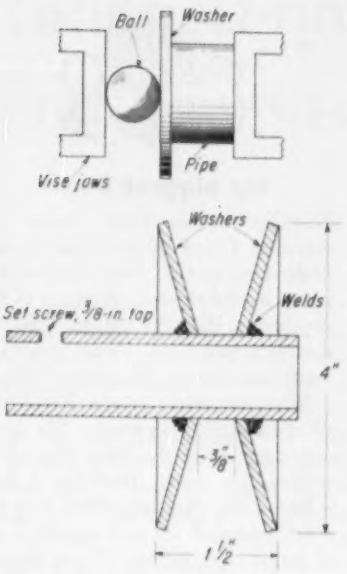
to POWER for the 32-page report on *Stationary Engineers' License Requirements in the U.S. and Canada* as it is out of print. But the McGraw-Hill Book Co has published the revised report—54 pages of chapter 20 in Part II of *Standard Plant Operator's Questions and Answers.*

Don't burn your packing

Normal stuffing box for jam type packing should have a flow (leakage) of from 40 to 60 drops per minute to act as lubrication and dissipate heat. Only time you need an external sealing liquid: if internal pump pressure acting against the inside of the stuffing box is negative, if liquid being pumped has solids in suspension or is highly volatile and a poor lubricant. See *Mechanical Packing*, POWER, March 1955, pp 107-130.

your tricky design and maintenance problems

STEVE ELONKA, Associate Editor



We made a V-pulley underground

Failure of hoist service almost threw us for a loop one Sunday. Riggers hauled the mile-long 1¼-in. rope off the drum, laid it in a flat loop in the snow for an end-for-end change to equalize the wear. Meanwhile, there we were in the mine, with the job of drilling four 2⅛-in. holes in the main frame of a haulage locomotive to replace an equal number of 1-in. cap screws. Screws had failed to support the cab and wouldn't stand up under tension imposed by tractive effort on the train.

Drilling through the solid malleable-iron frame would have been hard enough—no space to mount the "old man" to steady, guide and feed the air-motor drill. But reaming through really proved tough, even with speed control of an air motor.

On the last ream job the drill broke off squarely, one inch from the bit. We'd brought no spare into the mine, so some tedious grinding was needed to complete the job. One look at our air-powered grinder convinced us that we'd have to do a "Marmy" to repair or replace the broken V-pulley on the air motor. We couldn't go to the surface for another three hours with those riggers still working away at the rope change.

My sketches show how we used a ball from a scrap ball bearing to force washers into a cone shape forming the two sides of an improvised pulley. Hub was formed by chipping off broken malleable flanges of the original pulley. Arc welding assembled the parts and we were back in business in a very short time.

C ZIEMKE, *Clinton, Tenn.*

What would you have done?

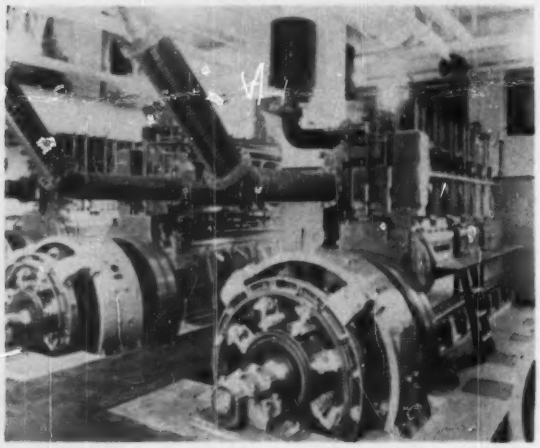
I was supt in a station that had been shut down for several months. We had to start up for a few days. Boiler-feed pump's outboard bearing went up in smoke. Gland packing had apparently dried; water got into the bearing, burning it. But that was only the start of things to come.

Feeder plate on boiler using pulverized coal jammed and stopped. Because some of our regular men had taken others jobs, we hired some willing but inexperienced firemen. Firemen had this happen often when running steady, but being out of practice they looked for something complicated, like burned out solenoids, etc. They only had to push the reset button. Load had to be dropped while raking coal into the pulverizer by hand, so maintaining steam pressure was almost impossible. While this was going on, a fireman tried to start the smaller mill. In his hurry he didn't roll it over by hand first. For some reason the overload protection didn't work. Then friction clutch wore the cast-iron outer part down until it actually disappeared. It operated by the blocks on the motor, throwing out and contacting the outer half of the clutch on the mill end. After a little time we corrected these small headaches.

Another fireman took coal from the bunker with the weigh larry. He hadn't closed the slide tightly so a little coal was trickling out of the bunker. When he pulled the chain to close the slide, he could only tug on the wrong one, which he did. This would only happen when the bunker was full. He pulled hard enough to knock the stop off. Slide came down to the floor with about 3 ft of coal for the length of the firing aisle on top of it.

While these interesting things were going on in the fireroom, other happy things happened in the turbine room. I assigned a man to help the operator start the turbine. He was experienced, had operated turbines before going into the maintenance end of the plant. Operator reported he could only get rpm if he lost vacuum. From previous experiences we thought that valves had rusted and stuck. Another turbine was put on the line. But in shutting down the first one the operator found that his helper had only cracked the main stop to the turbine, so there wasn't enough steam for vacuum and rpm. What did I do about all this? I went out and had three triple martinis made with locomotive Sandpaper Gin. What would *you* have done?

S KRONE, *Jamestown, N. D.*



Flexible hose took the jitters out of these diesels

Vibration posed a troublesome problem in a southern chemical plant. Piping shook so severely that anchors were pulled loose from the sheet-metal bulkheads, parting the bulkhead panels at the seams. Exhaust mufflers on the roof vibrated something awful until the engines were phased in.

Answer was stainless-steel flexible exhaust lines, designed especially for diesel exhaust piping. These flexible sections will absorb vibration of up to 5/8-in. lateral and 1/2-in. axial total amplitude in a length of 35 in. Hook-up, photo, solved vibration problem.

—*Courtesy, Allied Metal Hose Co*

My biggest boner

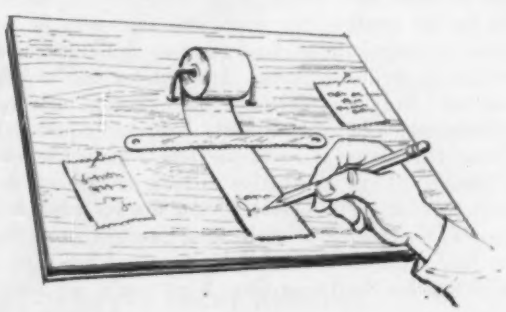
Working in the boiler room one morning I had to start the duplex boiler-feed pump. One side of the pump started to race. Jumping to the conclusion that the piston cups on that side were shot, I shut down the pump and started the electric pump.

When the chief came in, I told him what I thought was wrong. My relief also came in at the same time, so I headed for home thinking I had solved a big problem. Next day the chief presented me with a perfect set of piston cups, saying, "These are the cups you took out of that pump."

"They look like new," I said.

"You're right. And the next time you start a duplex feed pump, don't forget to vent it. Experience is the best teacher, and a fool learns no other way." My face was so red you could have called me Nikita.

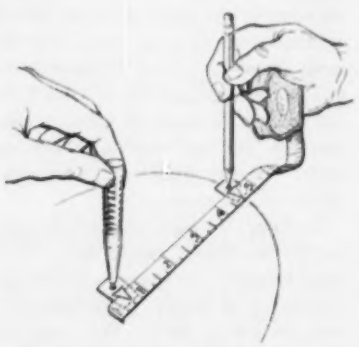
C TESSIER, *Indian Orchard, Mass.*



Handy shop desk can be made in a few minutes

Here's a very handy board for anchoring notes or job orders. It's out of the way and you won't lose work orders because you've left them on the bench or desk. You can park it by your phone and use it for writing. It's easy to tear off part of a message and just as easy to post new ones. All you need is a 12 x 24-in. piece of plywood, a coat hanger, one hacksaw blade and the paper roll from an adding machine, or wider paper. Then you have a portable desk.

J K NEAL, *Cuyahoga Falls, Ohio*



Let's draw large circles

For that occasional large circle, here's a solution. You can use your flexible steel tape in any length. Make the clamps shown in sketch. A prick punch and a pencil complete the tool. This idea has helped us many times.

J K NEAL, *Cuyahoga Falls, Ohio*

Teflon O-rings find new uses

Teflon O-rings have made remarkable progress as both dynamic and static seals since our 24-p special report, *Gaskets*, came out in March 1954. And no wonder.

They're made in over 300 standard sizes today, and also are available with a mirror finish—an exceptionally smooth surface without raised flash or other imperfections. On a moving part or dynamic seal the mirror finish provides more-precise tolerances, gives the O-rings longer life because of reduced friction. Sketches show some typical applications where seals help solve many tough problems.

Important characteristic of this plastic: nothing sticks to Teflon. Natural slipperiness reduces friction where oil can't be used, making rings ideal for dynamic applications. Grooves for Teflon O-rings are similar to those used for rubber, though there's less cross-section squeeze on the ring and groove is shorter.

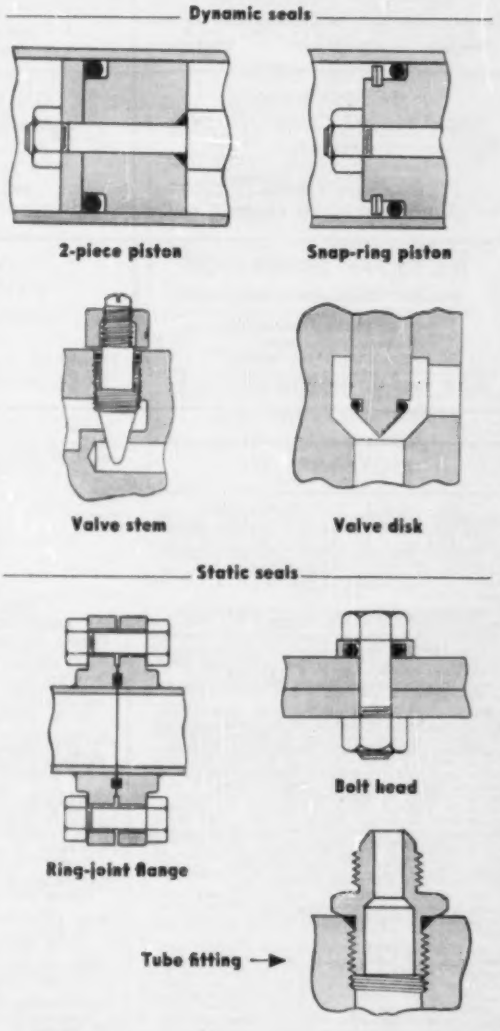
Biggest problem when using Teflon in an O-ring has been its inelasticity in comparison to rubber. But there are ways to simplify or get around this problem:

(1) In the cold-stretch method, ring stretches 5 to 10% of its diameter. This may be the solution where pressure falls on one side, in a faucet or valve application, right, for example.

(2) In the hot-stretch method, ring stretches 10 to 20% of its diameter when heated in boiling water or in a controlled oven at 200 F. This method is used where more-positive retention in groove is required, takes over where motion is reciprocating, as on slide valves or pistons, or where fluid pressure is brought to bear on both sides of the O-ring.

Teflon is a gaseous tetrofluoroethylene polymerized to yield a granular solid that can be compression molded. It shows superior chemical inertness from very low temperature, below zero, to 500 F and above. Only common commercial chemicals and solvents attacking it are molten alkali metals and fluorine at high temperature and pressure. High mechanical strength holds over a range from –300 to + 500 F. Below –300 F Teflon becomes brittle.

Typical applications for Teflon O-rings



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Circle 506 on Reader Service Card

WE PAY
$ CASH $
FOR
Electric Motors • Starters • Transformers
Circuit Breakers — Electric Supplies
ALLIED ELECTRIC CO.
710 N. MAIN ST., MEMPHIS, TENN.
BOX 1888 — PHONE JA 7-1681

Circle 507 on Reader Service Card

Wanted — TURBO GENERATOR

2500 to 3000 KW Inlet Steam Pressure 400# at 700° F PTT. Exhaust Steam Pressure 25#, 480 Volts, 3 phase, 60 cycle. Submit FULL specs., exact condition best price.

Also need several smaller units 400-500 KW, 150-200#, 10-15#, 440-480 Volts, 3 phase 60 cycle.

SUPERIOR PRODUCTS CO.
P.O. Box 357 Riverside Station, Miami 35, Florida

Circle 508 on Reader Service Card

Circle 501 on Reader Service Card

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CONVERSION & POWER EQUIPMENT

M-G SETS—3 Ph. 60 Cy.

Qu.	KW	Make	RPM	DC Volts	AC Volts
1	4000/4800	G.E. (SU)	450	250/300	2300/4600
1	2500	Whse. (SU)	720	600	2300/4600
1	3400	G.E.	450	300	2300/4160
1	1750/2100	G.E.	514	250/300	2300/4600
1	3000	G.E.	514	600	2300/4600
1	1500	G.E.	720	600	6900/13200
1	1800	Cr.-Wh.	720	100	2300/4160
1	1320	Whse.	720	600	2300/4160
1	1000	G.E.	900	600	2300/4000
1	1000	G.E.	720	250	2300/4160
1	1000	G.E.	600	300	4000/6600
1	500	G.E.	900	125/250	440
1	500	G.E.	900	250	2300/4000
1	500	G.E. (new)	1200	300	2300
1	440	C.W. (SU)	1200	125/250	2300
1	200	G.E.	900	125	440/4160
3	300	G.E.	1200	250	2300
1	300	Whse.	1200	600	2300/4160
1	200	G.E.	1200	250/275	440
1	300	G.E.	1200	250/275	2300/4160

MERCURY ARC RECTIFIERS

Qu	KW	Make	Type	DC Volts	AC Volts
3	150	G.E.	KP 30	345	500
1	100	G.E.	6KP	275	2300/4160

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltages
1	13500	Whse.	60/25/60	13200/13200
1	8000	G.E.	60/50/60	11000/6600
1	3000	G.E.	25/63¼	2300/2300

TRANSFORMERS

Qu.	KVA	Make	Type	Ph.	Voltages
3	2222	Whse.	OISC	1	13800x2300
1	3000	A.C.	OISC	3	84300x2300
3	1000	G.E.	OISC	1	13800x600
3	883	A.C.	OISC	1	2400/4800Y480

TURBO GENERATORS

Qu.	KW	Make	Description
1	1000	G.E.	Non Cond. 1250#/5-15# B.P. 250°F.
1	3000	G.E.	Cond. 400#-750° 2400/4160Y.

A.C. MOTORS — 3 Ph. 60 Cy. Slip Ring

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-979B5	4800/2400	1800
1	800	Whse.	CW	250	1775
1	800	G.E.	MT-428	2300	450
1	600	Whse.	CW-32D-15	440	1775
1	600	Whse.	CW	440	850
1	850	Whse.	CW	440	382
	(Unused)				
1	500	Whse.	CW	2300	880

SQUIRREL CAGE

1	350/375	Whse.	CR-1115	2300	450/900
1	300	G.E.	FT-850Y	2300	3600
3	300	Whse.	CHP-562H	440	3500
4	300	Whse.	CR-1216	2300	500
3	450	Elliott	3010	2200	1185
1	400	Whse.	CR-7151 4000/6600		3600
1	200	Whse.	CR-1062E	2300	880
1	300	G.E.	KT-859A	2300	1775

SYNCHRONOUS

1	7000	G.E.	ATI	2300/6600	600
1	3500	G.E.	TS-6497	2300/4000	300
2	1750	G.E.	ATI	2300	3600
1	325	G.E.	ATI	440	1800

RE-NU-BILT BY

BELYEA COMPANY, INC.

43 Howell St., Jersey City 6, N. J.

Tel: OLDFIELD 3-3334

Circle 509 on Reader Service Card

CHECK WITH WAGNER FIRST!

Thousands of new and "Certified Rebuilt" Motors & Generators in stock—up to 1000 H.P.

OUR 54th YEAR

A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
900	Whse. (2)	Sq. Cage	2300	1800
750	El. Machy.	Synch.	480	514
700	G.E.	Slipring	2300	514
600	G.E.	Synch.	480	900
600	Elliott (2)	Sq. Cage	2300	900
500	Al. Ch. 3 brg.	Slipring	440	514
500	Allis Ch.	Slipring	2300/440	600
400	Whse.	Sq. Cage	2300	514
400	Marathon (2)	Sq. Cage	2300	3600
400	G.E.	Slipring	2300/440	600
400	El. Machy.	Synch.	2300/4000	600
450	Allis Ch.	Sq. Cage	2300/440	720
350	El. Machy.	Synch.	2300	900
350	G.E.	Sq. Cage	2300	1800
300	G.E.	Slipring	220/440	514
250	G.E.	Sq. Cage	2300/440	1200
250	Gen. Elec.	Sq. Cage	440	3600
250	Whse.	Sq. Cage	2300/440	600
250	Whse. (4)	Slipring	2300/440	600
250	Gen. Elec.	Synch.	550/440	600
250	G.E. b.b.	Sq. Cage	220/440	720
200	G.E.	Slipring	220/440	450
200	G.E.	Slipring	440	600
200	G.E.	Slipring	2300	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	2300/440	720
200	A.C. TEFC	Sq. Cage	2300/440	1200
150	Cr. Wheeler	Sq. Cage	440	450
150	G.E. TEFC (2)	Sq. Cage	220/440	900
150	Whse. XP	Sq. Cage	440	3600
150	G.E. (4)	Slipring	2300/440	600
150	Whse.	Slipring	220/440	1200
125	Whse. b.b.	Sq. Cage	220/440	900
125	A.C. TEFC	Sq. Cage	220/440	1800
125	El. Machy. (2)	Synch.	220/440	600
125	G.E. TEFC	Sq. Cage	2300	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	600
125	G.E. (2)	Slipring	220/440	514
125	G.E.	Sq. Cage	2300/440	1200
100	Allis Ch.	Slipring	2300/440	600
100	Al. Ch. Tex-o-b.	Sq. Cage	2300	1800
100	G.E. TEFC-XP	Sq. Cage	220/440	1200
100	G.E. b.b.	Sq. Cage	220/440	3600
100	G.E. (2)	Slipring	220/440	1200

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
300	Gen. Elec.	CY-231	250/350	1200
200	Gen. Elec.	RC	250	1450
100	Delco b.b.	late	120/240	1200
75	Allis Ch. b.b.	EB-146L	125	1800
60	Ideal	D	125	1150
40	G.E. b.b.	CD	600	1750
30	G.E. (2)	CD-1129	250	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
250	Cr. Wh.	161-H	230	1150
200	G.E. (2)	BC-36	230	1150
200	Whse. b.b.	SK	250	287/575
150	Rel. TEFC b.b.	2550-P	230	850
150	Whse.	SK-510	230	330/1000
125/150	F.M. b.b.	DXZD	230	335/1200
125	G.E.	CD-172	230	575/1150
100	Elliott b.b. T.E.	JH-FE	230	1150
100	El. Dyn. b.b. (2)	30-S	230	450/1200
100	G.E. crane	CO-1831	230	675
75/100	Whse.	SK-101	230	300/900
60	G.E. TEFC b.b.	CD-126	230	1150
30/40	L.A. b.b. (2)	ONW	230	500/1500

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
300	G.E.	440 AC	250/350 DC
200	Allis Ch. (2)	440 AC	250 DC
200	Whse. synch.	220/440 AC	50 DC
200	Gen. Elec.*	220/440 AC	125 DC
125	Whse.	220/440 AC	250 DC
100	Delco b.b.	220/440 AC	120/240 DC
80	Star b.b. Synch.	220/440 AC	250 DC
75	Whse. Synch.	220/440 AC	250 DC
60	Ideal	220/440 AC	125 DC
50	Whse. synch.	220/440 AC	250 DC
30	G.E. (2)	220/440 AC	125 DC
30	Whse.	220/440 AC	250 DC

Arthur Wagner Co. Certified

MO nroe 6-7409

1435 W. RANDOLPH ST.

CHICAGO 7, ILLINOIS

Circle 510 on Reader Service Card

ELECTRICAL POWER EQUIPMENT

SLIP RING MOTORS

3 ph 60 cy 220 or 440 volts

HP	RPM	MAKE	TYPE
1500	514*	Al.-Ch.	Mill Type
1300	360*	Al.-Ch.	Mill Type
900	180*	Al.-Ch.	Mill Type
600	1800*	Gen. Elec.	M-6345S, Dppf. New
500	1200	Gen. Elec.	M-6945Z, Dppf.

*2200 volts or higher

SQUIRREL CAGE MOTORS

3 ph. 60 cy. 220 or 440 volts (*2200 volts or higher)

HP	RPM	MAKE	TYPE
1250	3600*	Al.-Ch.	ANX
800	1800	West.	CS24C
600	600*	West.	CS-44-C15 Dppf (3)
500	1200	G.E.	I-K
400	1800*	L. Allis	BB, Sppf.
400	1800	West.	BB. Dppf.

MOTOR GENERATOR SETS

KW	Make	Motor A.C.V.	Generator D.C.V.
1000	West.	4160	230
600	G.E. (3 unit)	2300/440syn.	125/250
500	West.	2300/440syn.	125/250
400	Al.-Ch.	2300/440syn.	125/250
300	West.	2300/480syn.	250
200	Rel.	2300/440syn. T8	300
200	G.E.	2300/440syn. T8	250/275

TRANSFORMERS

Special Offer — Like New

3—1250 KVA Allis Chalmers Class OA Oil filled 3ø1 ph 60 cy 34,000 Volt primary, 480 volt secondary with taps, manufactured 1955.

Our 50th Year 1910 to 1960

Write for current complete stock lists on electrical power equipment you need or send your list of surplus and used equipment for our offer.

Phone CAnal 6-2900

CHICAGO Electric Co.

1320 W. CERMAK ROAD • CHICAGO 8, ILL.

Circle 511 on Reader Service Card

DIESEL GENERATOR SETS

(4) NEW 500 KW GM 8-278

Engines — 715 HP — Vee type — 8 cylinder — 8½ x 10½ — air starting — 720 RPM — 2 cycle — heat exchanger cooled. Engines drive 500 KW Allis-Chalmers D.C. generators—120/240 — 2080 amps — 720 RPM — compound wound. Complete with a very generous supply of spare parts. IF YOU NEED D.C. POWER, NOTHING CAN BEAT THIS VALUE. FULLY GUARANTEED.

NOTE:

We can also quote you using the above engine — radiator cooled and with an A.C. generator — either 440/2300 or 4100 — and offer a completely portable unit.

EXCELLENT GENERATORS FOR STANDBY POWER

(1) UNUSED 250 KW UNIT

440/3/60 — 900 RPM Westinghouse generator — driven by a Cooper-Bessemer 8¾ x 11 engine model F.S.6 — Heat exchanger cooled. This is an unused set in prime condition. Will demonstrate. Unit is a slow-speed heavy duty diesel generator.

(2) AS ABOVE, RECONDITIONED

Send us your inquiries

THE BOSTON METALS CO.

313 E. Baltimore St., Baltimore 2, Md.

ELGIN 5-5050 LEXINGTON 9-1900

Circle 512 on Reader Service Card

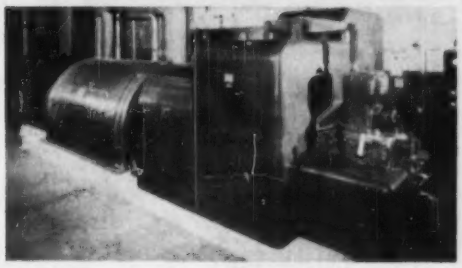
Modern 850lb. 850.—6250 K.V.A. Turbine Generator

125 to 160 lb. Back Pressure

Immediately

Available

Excellent Condition



Actual Photograph

Generator

3/60/2400, 80% P.F.

Built by Westinghouse

Other turbine Generators

1-2000 KW GE	600#750° Non-Cond. 150# BP 4160V/6600V
2-3000 KW Westinghouse	600# 750° Non-Cond. 125/150# BP 2400V
1-2500 KW Allis Chalmers	400# Autext 150° Non-Cond. 30# 480V
1-2500 KW Westinghouse	125# Non-Cond. 10# BP 2300V
1-2500 KW GE	400# 750° Autext 25# Condensing 600V
1-6000 KW GE	200# Condensing 2300V
1-7500 KW Allis-Chalmers	850# 850° Non-Cond. 110# BP.

1-15,000 KW General Electric 850 lbs. 850°, 3/60/13,800 Volts

Cable Address: CHASWEAVER

CHARLES WEAVER, INC.

19701 JAMES COUZENS HIGHWAY

DETROIT 35, MICHIGAN

Telephone: BRoadway 3-1900

Circle 513 on Reader Service Card

BOILERS

From the unfinished Battle Cruiser "Hawaii"

Material installed completely and never used.

8 Babcock & Wilcox Watertube Boilers

Approximately 157,000 lbs/hour. Working pressure 600#—850° T.T.—Oil-fired—with all boiler trim. Units are complete with fuel oil burning equipment—feed water pumps—feed water heaters, etc. Units are in prime condition.

CAN BE LOADED AS A UNIT OR DISMANTLED AND SHIPPED IN SMALLER SECTIONS

THE BOSTON METALS CO.

313 E. Baltimore St., Baltimore 2, Md.

ELGIN 5-5050 — LEXINGTON 9-1900

Circle 514 on Reader Service Card

MOTORS • GENERATORS TRANSFORMERS NEW • REBUILT

ELECTRIC EQUIPMENT CO.

WORLD'S LARGEST INVENTORY

CALL COLLECT GL 4-9058

P.O. BOX 51 • ROCHESTER 1, N.Y.

Circle 515 on Reader Service Card

UNUSED—ASSEMBLED—NEW

IN ORIGINAL MANUFACTURER'S PACKING CRATES

BOILERS (Package type)

B&W—60,000 lbs./hr.—475 psig., 740°TTF, oil fired (shipped intact as one integral unit)
B&W—122,500 lbs./hr.—635 psig., 850°TTF, oil fired (unassembled)
B&W—153,000 lbs./hr.—634 psig., 850°TTF, oil fired (unassembled)

TURBOGENERATORS

4600 KW GE Turbine—Gen Set, Cond 410psi, 725°TTF, 28.5 Hg exh, 3/93.3/2700V PF 1.0—New
1800 KW GE Turbine—Gen Set, Cond 410psi, 725°TTF, 28.5 Hg exh, 3/60/1735 V PF 0.8—New
1500 KW Westinghouse—Gen Set, Non Cond 400psi, 3/60/480V PF 0.8
1000 KW Westinghouse Turbine Gen. Set, Non. Cond. 190psi, 600°TTF, 3/60/480V/3600RPM PF 0.8

STEAM TURBINES

1000 SHP GE Cruising Cross Compound, 525psi, 825°TTF, 61psi exh, 10,119/350 RPM with Falk reduction gears—New
3000 SHP GE HP Main propulsion turbine 410psi, 9040RPM, 725°TTF
3000 SHP GE—LP Main propulsion turbine 40psi, 9040RPM } 1 Set—New
11,550 SHP GE HP 12 Stage Cross compound turbine 525 psig, 825°TTF 5870RPM
13,450 SHP GE LP 48psig, 4714RPM with Westgh speed decreaser gear assy. } 1 Set—New
294 HP Worthington-Moore, Non-Cond. Form 2S2R, 310psig, 650°TTF, 2psi-exh, 3560RPM
250 HP Sturtevant non-condensing Turbine—575psi, New

PUMPS, CENTRIFUGAL (Motor driven)

263 GPM @ 375'TDH, Ingersoll Rand—2GT, w/60HP 3525RPM 3/60/220/440V (Used)
275 GPM @ 635'TDH, Ingersoll Rand—2GT, w/75HP 3525RPM 2/60/2300V (Used)
200 GPM @ 1300'TDH, Ingersoll Rand—½CNTA, w/Base, Motor optional

PUMPS, CENTRIFUGAL (Turbine driven)

460 GPM @ 750psi discharge, Worthington, w/350HP turbine, 575psi, 4900RPM—New

BLOWERS, TURBO-CENTRIFUGAL

20,000 CFM @ 17"WC, Westinghouse, Vaneaxial, w/Turbine, 82.5HP, 375psi, 10psi—exh, 4625RPM—New
24,000 CFM @ 26"WC, Sturtevant Co, Rexvane, w/Turbine, 191HP, 490 psi, 10psi—exh, 3525RPM—New
31,250/24,000 CFM @ 45"/28" W.C. Sturtevant Propeller-Fan w/1862HP, 575psi, 15psi exh, 5850/4800RPM

WABASH POWER EQUIPMENT CO.

9750 SKOKIE BLVD., CHICAGO, ILLINOIS—TEL. OR 3-8118

3757 Wilshire Blvd. Los Angeles 5, Cal. | 1684 Hudson San Francisco, Cal. | 730 Dearborn Seattle, Washington

Circle 516 on Reader Service Card

37 Years Dependable Service

SLIP RING MOTORS 3 Ph., 60 Cy.

H.P.	Volts	Make	Speed
500	4000/2300	G.E.	600
450	4000/2300	G.E.	1200
400	2300/440	G.E.	600
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	600
200	2300/440	G.E.	720
125	2300	G.E.	600

AC GENERATORS or SYN MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
600	2300	G.E.	TS	1800
400	2300/440	G.E.	ATI	720
300	2300/440	G.E.	TS	1200
200	440	G.E.	TS	600
150	440/220	Whse.	G	1200
125	440/220	Whse.	HH	400

SQUIRREL CAGE MOTORS

500	2300/4000	Elliott	SC	1800
400	2300	G.E.	FT	3600
400	2300/4000	G.E.	K	1200
350	2300/4000	G.E.	SKDP	3600
350	2300/4000	G.E.	K	900
300(2)	2300	G.E.	FT	3600
300	2300/4000	L. Allis.	FS	1800
300	2300/4000	Cont'l.	Spl.-Prf.	720
300	2300/400	G.E.	KT	1800
250	2300/4000	G.E.	K	720
200	2300	G.E.	KT	1800
200	2200	Cont.	TEFC	3300
150	440	Whse.	X-pf.	3600
150	440/220	Cont'l.	X-pf.	1800
150	440/220	G.E.	TEFC	720
150	2300/440	G.E.	TEFC	3600
125	2300/440	G.E.	FT	1200
100	440	Whse.	X-pf.	3600
100(3)	440	Cont.	X-pf.	1800
100(3)	4000/2300	L. Allis	OX	1200
100	2300	Cont'l.	OX	1200
60(3)	440	Cont'l.	X-pf.	1800

CIRCUIT BREAKERS, 3 Pole

4—1600 Amp., DA-50, Whse., 600 V., Air
1—600 Amp., G.E., 15 KV, Sel. oper.
2—600 Amp., G.E., 15 KV, manual
1—600 Amp., Whse., 7.5 KV, outdoor, New.

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
150	230	El. Dyn.	B/brg.	850
90	220	G.E.	CD	1750
50	220	G.E.(4)	CD	1150

MOTOR GENERATOR SETS

		Input., Motor	Output V.,
KW	Make	AC Type	DC
300	Whse.	4160/400 Syn.	250/125
150	G.E.	440/220 Syn.	250
125	G.E.	440/220 Sq. Cn.	125
100	G.E.	2200/440 Syn.	250
75	Cr. Wh.	440/220 Sq. Cn.	240/120
65	G. E. B	2200/440 Sq. Cn.	250

TRANSFORMERS 60 Cy.

1—500 kva. Al Ch. 2400/4160Y—600 volts, 3 ph.
2—500 kva. G.E., 13800—240/480 V.
1—200 kva. Mol., 13,800—2300 V.
3—333 kva. G.E., 13,800—2400 V.
3—333 kva. G.E., 2400—240/120 V.
3—333 kva. Mol., 2400—240/480V.
2—200 kva. G.E., 2400—480Y. Pyr.
5—200 kva. G.E., 13,800—480 V.
2—200 kva. G.E. 4150—480/240 V.
2—167 kva. Whse., 4150—480 V
3—150 kva. Al. Ch., 2400—220 V.
3—150 kva. G.E., 13,200—2300 V.
2—100 kva. Whse., 2400—240/480 V., Dry
3—100 kva. G.E. 2400—120/240 V., Pyr.

GASOLINE—ENGINE GENERATOR SETS

3—37½ kva. 1800 R. 230 V 3/60, Cont'l., 6 cyl.

only partial listing

STEPHEN **HALL** & CO.
HARRY J. RICE, Pres.
625 ADAMS ST., HOBOKEN 2, N. J.

Circle 517 on Reader Service Card

TRANSFORMERS

BOUGHT · SOLD · RENTED

REWOUND · RE-DESIGNED

MANUFACTURED

Ask for our Stock List

For Sale

3—2500 KVA G-E 69000—2300Y
3—2500 KVA G-E 69000—2400/4160Y
3—2500 KVA G-E 69000—7200/12470Y
4—2500 KVA W-H 34500—2400/4800/11000
3—1500 KVA G-E 69000—2300Y
3—1500 KVA G-E 69000—2400/4160Y
3—1500 KVA G-E 69000—7200/12470Y

THE ELECTRIC SERVICE CO., 5322 Hetzel St., Cincinnati 27, Ohio
"America's Exclusive Independent Transformer Service Shop"

Circle 518 on Reader Service Card

TRANSFORMERS—60 CYCLE

Qu	KVA	Make	Type	Phase	Voltages
2	3000	Moloney	TCR	3	7200/6600-4160/3800
3	50	Amer.	WF Dry	1	460/230-230/115
6	37½	G.E.	Dry	1	460/230-230/115
3	333	G.E.	HK		2400/4160-240/480
5	200	Al.-Ch.	CBS	1	2400)/4160-240/480
3	100	Amer.	CC	1	4160/7200-240/480
3	75	G.E.	KP	1	2400/4160-120/240
1	50	Amer.	Absetal	3	4160-120/208Y
2	50	Niagara	Dry	1	2400/4160Y-120/240
3	50	Harrison	Dry	1	2400/4160Y-220/440
2	3000	G.E.	OA-T	3	28,400-4160/2400
6	25	G.E.	Dry	1	2200-440

MOTOR GENERATOR SETS

Qu	KW	Make	Speed	DC	AC
1	75	EM	1200	250	Syn. 220V.
1	75	G.E.	1200	125	2300/4160 Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y SR
1	300	Al.-Ch	1200	125/250	Syn. 440V.
1	1000	West.	720	600	2300/4160Y Syn.

ENGINE GENERATOR SETS

1—Hercules Gas HXE 62.5 KVA Weight 3/60/480 —1200

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	600	CW	220/440
1	60	G.E.	1800	MT	220
1	60	G.E.	880	MT546	440
1	75	G.E.	600	IM	440
1	100	West.	1800	T.E.F.C. B.B	220
3	150	Allis-Ch.	1800	AY-HW	2300
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	450	West.	1800	CW-4-30-9	220
1	500	G.E.	450	MT	2300
1	300	G.E.	1200	M360Z	2300/4160Y
1	30	G.E.	870	MT352	220/440

D. C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	350	G.E.	1200	Pedestal
1	30	G.E.	1750	173 FR
1	30	West.	890/1400	SK-601343

SQUIRREL CAGE MOTORS, 3 PHASE, 60 CYC.

1—300 HP, 1200, Allis. Chalmers, 2300/4160Y
1—275 HP, 1130 RPM G.E. Type KT 580BS 2300V
2—200 HP, 1790 RPM, G.E. Elec. KF, TEFC, 2300V
2—150 HP, 1800 G.E. TEFC Exp. 220/440
1—100 HP, 1775 RPM G.E. KTP-543 3 ph 60-440V.
1— 75 HP, 3600 RPM Cont. MP 505—440V Exp. P
1— 50 HP, 3600 Cont. Ex. Pr. 220/440
2—100 HP, 3600 RPM Cont. NP 535-B 440V X.P.
1—100 HP, 1200 RPM West-CSP 220/440
1—300 HP, 450 RPM GE TS 7656-2300

MOTORS—SYNCHRONOUS—3 ph. 60 cy.

100 HP 900 RPM G.E. Pum BL 2200V.
125 HP 600 RPM G.E. Type TS 2200 V.
125 HP 900 RPM Elect. Mach. 4800 V.
150 HP 3600 RPM G.E. type TS Fr. 954Y 2300 V.
150 HP 1800 RPM G.E. Type TS 230 V.
200 HP 720 RPM Elec. Machinery L.r.f.e. 2300 V.
325 HP 900 RPM West—2300 V.
400 HP 450 RPM Westinghouse Type HR 440 V.
75 HP 1200 RPM Crocker-Wheeler Type ALT 220/440 V. B.B.

FOR POWER
J.L. HEMPHILL & CO.

Circle 522 on Reader Service Card

BOILERS NEW UNASSEMBLED

# Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.

H Header type, straight tube, B & W.

A 3 drum, single furnace, Wickes.

Pelnik-Loconti Industrial Supply, Inc.
315 Oriskany St., Yorkville, N.Y.
Utica, N. Y. Ph. RE 6-4621, RE 2-4513

Circle 519 on Reader Service Card

MODERN POWER BOILERS

2—Babcock & Wilcox	—285,000#/h—	750 psi
1—Combustion-Engineering	—110,000#/h—	675 psi
1—Riley	—100,000#/h—	450 psi
1—Babcock & Wilcox	—100,000#/h—	450 psi
1—Babcock & Wilcox	— 90,000#/h—	265 psi
1—Combustion-Engineering	— 75,000#/h—	250 psi
1—Babcock & Wilcox	— 70,000#/h—	450 psi
1—Riley	— 60,000#/h—	265 psi
1—Combustion-Engineering	— 54,000#/h—	250 psi
2—Combustion-Engineering	— 50,000#/h—	250 psi
1—Babcock & Wilcox	—45,000#/h—	450 psi
1—Foster-Wheeler	— 40,000#/h—	200 psi
2—Babcock & Wilcox	—40,000#/h—	250 psi
1—Babcock & Wilcox	— 27,500#/h—	450 psi
1—Edgemoor	— 25,000#/h—	450 psi
2—Riley	— 21,000#/h—	250 psi
3—Riley	— 18,000#/h—	200 psi

MIDWEST BOILER & TURBINE CO.
WARNER, NEW HAMPSHIRE

Circle 520 on Reader Service Card

3—Used 2300/3/25, 1450 RPM, slipring, Westinghouse motor driven 3000 GPM, 2 stage, 700 ft. head, Worthington centrifugal pumps.

3—Used 740 HP, 250 PSIG steam pressure, non condensing, Terry turbine driven, Manistee, 3000 GPM, 720 ft. head, 4 stage, 1500 RPM centrifugal pumps.

Electrical switch gear, steam and water piping included.

For details, write to Director of Water, 504 City Hall, Buffalo 2, New York.

Circle 521 on Reader Service Card

FOR SALE

1500 KW, 80% Power Factor, 3 phase, 60 cycle, 2300 volts, 3600 RPM, General Electric 5-stage noncondensing steam turbine generator unit, 375 PSIG, 700° FTT, 125# exhaust back pressure, complete with direct connected shaft exciter and switchgear. Excellent condition—available immediate delivery.

EUCLID ENGINEERING CORPORATION
909 National City East Sixth Building
Cleveland 14, Ohio

Circle 523 on Reader Service Card

(3) 622 H.P.
HIGH PRESSURE
BOILERS

For Sale Cheap! Now operating. Must be removed soon.

Also 1 WORTHINGTON STEAM DRIVEN AIR COMPRESSOR; 1530 CFM.
1 CHICAGO PNEUMATIC AIR COMPRESSOR No. 3. 1123 CFM. Motor driven. 222 H.P.

Write for Descriptive Circular

CLEVELAND WRECKING CO.
702 Chester Pike, Sharon Hill, Pa.
Phone SAratoga 9-2700

Circle 524 on Reader Service Card

NEW EQUIPMENT FROM THE UNCOMPLETED

BATTLESHIP U. S. S. KENTUCKY

Installed but never used
Built of finest materials

WESTINGHOUSE 1250 K.W. TURBO-GENERATORS

(4)—Westinghouse—440/3/60—850*—540 lbs. working pressure. Complete with condensers, circulating pumps, etc.

BOILERS

7 B&W EXPRESS TYPE

Design pressure 634# — operating pressure 565# — temp. 850°F. Oil fired — separately fired superheaters. *Capacity: 210,000 lb.* steam/hr. ideal for testing where large quantities of steam are required, giving excellent control from separately fired superheaters. Can be converted for #2 oil and natural gas. Fully automatic.

LARGE DEAERATING FEED HEATERS

Monel construction—spray type—capacity 480,000 lbs./hr.—vent condenser—single pass —heating surface 174 sq. ft.—all Monel construction.

GE HIGH AND LOW PRESSURE MAIN PROPELLING TURBINES

Will sell separately for testing, wind tunnel or similar work. (2) high pressure—24,400 HP—12 impuse stages—4909 RPM—working pressure 540 lbs.—825°F. (2) low pressure—28,600 HP — 3913 RPM — working pressure 49 lbs. steam—424°F—2-6 stages of impulse.

FEED PUMPS

Ingersoll-Rand—5"—three stage—500 GPM at 750 lb. discharge. BHP 330—5000 RPM—Worthington turbine—573 lbs.—non-condensing—back pressure 20 lbs.

FORCED DRAFT BLOWERS

29,000 CFM—max. static 35"—normal 21"

LUBE OIL COOLERS

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ELGIN 5-5050 — LEXINGTON 9-1900

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Gas or DIESEL GENERATOR UNITS
Complete Switchboard Design and Construction
USED & REBUILT EQUIPMENT
UNIVERSAL POWER ENGINEERING CO.
282 Wayne St. Jersey City, N. J.
Phone: DElaware 2-8300

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1050 HP FAIRBANKS-MORSE DIESEL MODEL 32, 7 CYL., 257 RPM, 726 KW, FM 3/60/2400 WITH EXCITER, SWITCHBOARD, ETC. VERY LOW PRICE.

3000 CFM WORTHINGTON AIR COMPRESSOR 2 STAGE, HORIZONTAL, 164 RPM, 5 STAGE CONTROL. 650 HP 3/60/440 SYNCHRONOUS MOTOR. COMPLETE ACCESSORIES.

WHISLER EQUIPMENT CO.
1908 Railway Exchange Building
St. Louis 1, Mo.

Circle 527 on Reader Service Card

MISS POWER EQUIPMENT SAYS,

"For BIGGER SAVINGS and BETTER SERVICE, Get Our BARGAIN PRICES on Guaranteed NEW and REBUILT MOTORS"

SQUIRREL CAGE MOTORS
NEW AND GUARANTEED

HP	Make	REBUILT	Type	Speed
500	G.E. S.B. Open		IK	1200
400	West. B.B. Drip		CSP-681	1800
400	L.A. B.B. Splash			1800
400	G.E. S.B. Open		IK	1200
400	West. S.B. Open		CS	900
350	West. B.B. Drip		CS-22556H	1200
300	L.A. S.B. Splash		FX-1465	1800
300	G.E. S.B. Open		IK	1800
300	G.E. S.B. Open		IK	900
300	Cont. B.B. Splash		N-804	900
300	G.E. S.B. Open		IK	720
300	G.E. S.B. Open		KT-561	720
300	G.E. S.B. Open		IK	600
250	G.E. S.B. Open		KT	1800
250	West. B.B. Splash		CS-875	1800
250	G.E. S.B. Open		IK	1200
250	G.E. S.B. Open		IK	900
250	G.E. S.B. Open		IK	720
200	G.E. B.B. Drip		K-6325	1800
200	West. S.S.B. Open		CS-855	1800
200	Cont. TEFCBB		NF-743X	1200
200	West. S.B. Open		CS	1200
200	G.E. S.B. Open		IK-15	1200
200	G.E. S.B. Open		IK-156	1200
200	G.E. S.B. Open	2200 v.	IK	1200
200	G.E. S.B. Open		IK	900
200	A.C. B.B. Open		AR-826	1200
150	West. TEFCBB		CS-81209	1800
150	G.E. S.B. Drip		K-6324	1800
150	West. S.S.B. Open		CS-771-C	1800
150	Al. Chal. B.B. Open		AR	1800
150	West. S.B. Open	2200V	CS	1800
150	West. B.B. Drip		CS-772	1200
150	West. TEFCBB		CS-775	1200
150	G.E. S.B. Open		KT	1200
150	G.E. S.B. Open		KT-557	1200
150	Al. Chal. B.B. Open		AR-826	900
150	Cont. TEFCBB		N-743-X	900
150	Al. Chal. TEFCBB		AZ	900
150	F.M. B.B. Open		H-24A	900
150	G.E. S.B. Open		IK	900
150	G.E. S.B. Open		IK	720
125	G.E. TEFCBB		K	3600
125	Burke S.B. Open	440 Volt	N-505	3600
125	Reliance T.E.F.C. B.B.		AA-5684	1800
125	G.E. S.B. Open		IK	1800
125	G.E. S.B. Splash		K-505	1800
125	Al. Chal. S.B. Open		AR	1800
125	G.E. S.B. Open		KT-553	1200
125	Century B.B. Drip			1200
125	G.E. S.B. Open		IK	1200
125	Ideal B.B. Open		A-585	1200
125	F.M. B.B. Open		H	900
125	G.E. S.B. Open		IK	720
125	G.E. S.B. Open		IK	600
100	Al. Chal. T.E.F.C. B.B.		ARZ-823	3600
100	C.W. B.B. Open	2300 Volt	SC-445	3600
100	L.A. B.B. Drip	New	OGX-445	3600
100	G.E. S.B. Open		KT-343	1800
100	G.E. B.B. Open		K-504	1800
100	Cont. TEFCBB	KP	NP-505	1800
100	Al. Chal. B.B. Drip		ARW-823	1800
100	G.E. S.B. Open		KT-347	1200
100	Ideal B.B. Drip	New	A-584	1200
100	West. S.B. Open		CS-667	1200
100	West. S.S.B. Open		CS-7454C	900
100	Al. Chal. T.E.F.C. B.B.	XP	23E8	900
100	F.M. B.B. Open		H20C	900
100	Al. Chal. B.B. Open		AR-823	900
100	F.M. B.B. Open		H	720
100	F.M. B.B. Open		H	600
75	G.E. B.B. Open		K-445	1800
75	Ideal B.B. Drip	New	A-505	1200
75	A.C. B.B. Splash		ARWW-443	1800
75	Master B.B. Splash		PA-505	1200
75	G.E. B.B. Open		K-505	1200

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8 CAIRN STREET • PHONE BEverly 5-1662 • P.O. BOX 534 • ROCHESTER 2, N.Y.

Circle 531 on Reader Service Card

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- 2—B. Keeler 200 HP water-tube boilers, 100 psi, Stoker fired, 1945.
- 1—KVS—7' x 9' Ball Mill
- 1—Babcock & Wilcox #32E coal pulverizer, air swept, 75 HP.
- 1—24" x 538' long trough belt conveyor.

PERRY EQUIPMENT CORP.
1422 N. 6th St., Philadelphia 22, Pa.
Phone: POplar 3-3505

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AUTOMATIC VOLTAGE REGULATORS

Complete stock of Allis Chalmers, General Electric and Westinghouse, new — unused. Save $$$

ELECTRIC POWER EQUIPMENT COMPANY
15 SO. ELM ST. DENVER 22, COLO.

Circle 529 on Reader Service Card

FOR SALE

1050 KVA DIESEL UNIT

1050 KVA Nordberg supercharged diesel engine generator unit, 3 phase, 60 cycle 2400 volts, 327 RPM.

New 1947 — Excellent condition.

The above unit is still installed and complete with all auxiliaries as in operation. Can be adapted for dual fuel operation.

International Power Machinery Co.
1612 Union Commerce Bldg.—MAin 1-9514
Cleveland 14, Ohio

Circle 530 on Reader Service Card

POWER EQUIPMENT

15000 KW, **NEW**, Cond. Turbo-Generator 3/60, 13800 V, 3600 RPM, 850 PSIG, 900°TT with boiler.
5500 KW, G.E., Non C. Turbo-Gen. 3/50, 2300 V, 3000 RPM 600 PSIG 650°TT, 150 PSIG Exh.
1000 KW, Worth.-Moore, Cond. Extr. Turbine, 3/60, 245/490V, 3600 RPM 130-300 PSIG, 10# Extr.
1000 KW, G.M. 16-278A, Diesel Units(2) 3 ph. 60 cycle, 2300 V, 720 RPM
300 KW, G.M. 8-268A, Diesel Units (2) 3 ph. 60 cycle, 480 V, 1200 RPM
500 KW, .8 P.F. West. 3/60, 240/480 V 300 RPM, Gen. direct conn. to Ames Verticol Uniflow Engine.

BREW, WOLTMAN
& COMPANY, INC.
50 CHURCH ST., N.Y. 7, N.Y.

Circle 532 on Reader Service Card

COMPRESSORS

No better values at any price

100 CFM	150 PSI 6x7 Ing. ES-1
138 CFM	100 PSI 7x7, Ing. ES, CP & Joy
288 CFM	100 PSI 8x8 Ing. Worth. CP
321 CFM	125 PSI 10x11 Ch. Pn. T
351 CFM	350 PSI 11-5x11 CP TCB-2
364 CFM	100 PSI 10x9 Joy WG9
485 CFM	100 PSI 12x11-1R-ES-1°Chic. P.T.
502 CFM	125 PSI 12x13 Worth HB
563 CFM	125 PSI 13½-8½x8 Worth DC2
660 CFM	125 PSI 11½-7x7 Joy Wa 102
696 CFM	100 PSI 14x13 Ing. ES
877 CFM	125 PSI 17-10½x14 IR. XRB-CV
1055 CFM	110 PSI 18-11x12 Ch. Pn. OCE
	175 HP 3-60-208 (Excellent)
1050 CFM	60 PSI 13-13x12 IR. XRE
1665 CFM	100 PSI Fuller—C-300-350H
	300 HP Syn 3-60-440 .8 PF

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UN 5-1397

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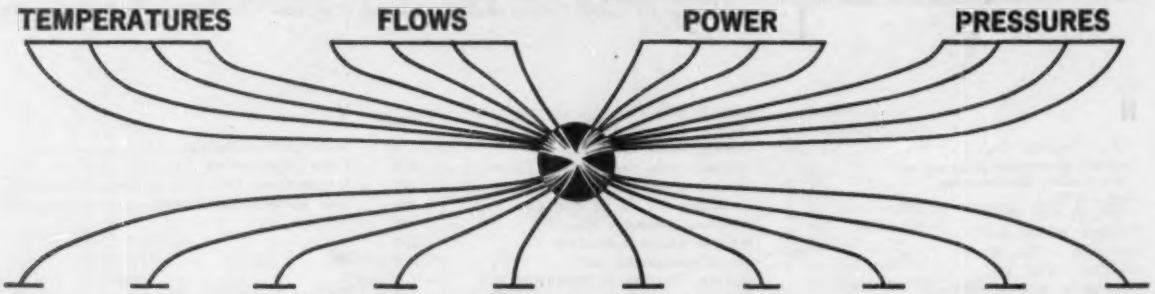
KYBERNETES SERIES 2000



Gross Sta. Gen. (KwHr) X 1000	Net. Sta. Out. (KwHr) X 1000	Sta. Load (Kw) X 100	Bus Volt. (V) X 10	Sta. Heat Rate (Btu/KwHr) X 10	Turb. Throt. Press. (psig) X 10	Turb. In. St. Temp. (°F) X 10	Cond. Circ. W. Temp. (°F) X 0.1	Feed Water Flow (lb/hr) X 10,000	Feed Water Press. (psig) X 10
225	195	303	416	870	225	105	619	130	250
225	195	303	416	870	225	105	618	130	250
224	195	302	416	870	224	104	620	130	250
225	195	303	416	870	225	105	619	130	250

DATA PROCESSING SYSTEM

√ MORE FEATURES
√ GREATER FLEXIBILITY
√ HIGH RELIABILITY

Here are the specifications . . . check how much more you get—in Kybernetes

1. Inputs—May be AC, DC, or Digital. Input range—zero to 10 millivolts minimum full scale; 0 to 1 volt maximum full scale.
2. Input Selection—Relay matrix type—individual hermetically sealed plug-in relays.
3. Remote Selector Switch—The input selector switch may be located remotely.
4. Analog to Digital Conversion—Electronic sweep voltage technique.
5. Linearization—Special linearization functions for all types of thermocouples are available. Linearization is to ±1°F over the full range of the thermocouple type.
6. Read-out and Control Panel—Rack mounted as standard, or remote console mounted. Special functions available as required.
7. Output Devices—Typewriters, adding machine type printers, tape punch, card punch or magnetic tape systems.
8. Programming—Pin board programming is standard for full scale ranging, zero suppression, alarm set points (high and/or low), trend logging and function programming. The latter includes provision for linearization, square root extraction, amplifier gain, number of digits logged, computations, and associated requirements.
9. Alarm Comparison—Alarm comparison is accomplished by the digital comparison of the output of the analog to digital converter against the set point established on the pin board programming system. Alarm protection is in operation 100% of the time.
10. Frequency of Periodic Log Cycles—Adjustable from OFF, 5, 10, 15, 30, and 60 minutes. Continuous or single cycle logging available from the on-demand log pushbuttons.
11. Input Capacity—Expandable from 10 inputs up in multiples of 10.
12. Rate of Scanning—Four points per second for off-normal conditions when no other functions are in operation; 3 to 4 points per second for off-normal scanning when auxiliary operations are in effect. Logging at one point per second as standard; other output devices in accordance with the capacity of the device up to four points per second.
13. Integration Sampling Rate—Each point every 10 seconds.
14. Special Sampling Rates—Higher sampling rates available through parallel operation. Simultaneous real time read-out of any quantity of variables available through individual analog storage devices at the input to the system.
15. Hazardous Locations—The system is designed for operations in Class 1, Division 2, Locations (Group D atmospheric mixtures), as defined in the 1956 National Electric Code, the Standard of the National Board of Fire Underwriters.
16. Power Requirement—120 volts, 50 or 60 cycles, single phase, 600 watts. A Zener diode referenced power supply provides a regulated output to within ±0.01%.
17. Accuracy—Over-all accuracy is ±0.1% of full scale. The following tabulation will be useful in evaluating the stability and accuracy of the Kybernetes data systems.

	Maximum drift—%	
	24 hrs.	6 mos.
Chopper Amplifier	.02	.16
Sweep Generator	.05	.07
Comparator	.0016	.0016
Pulse Generator	.001	.001
Gaging Function	.001	.001
Counters in Storage	.000	.000
Reference Voltages	.01	.01
Reference Oven (Thermocouples only)	.06	.06

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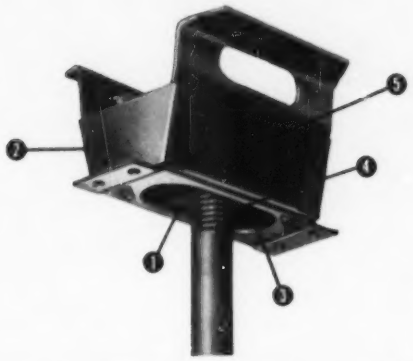
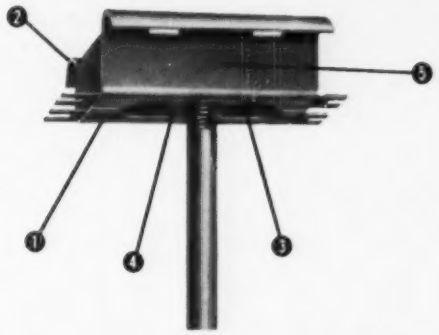


GRINNELL WEDGE TYPE CONCRETE INSERT (Steel), FIG. 281 — 1. Nut and rod may be preassembled for fast installation 2. Wedge-shaped body compresses in concrete for extra strength 3. Knockout (already removed) seals out concrete 4. Full 1¾ inch lateral adjustment 5. Supports up to 1200 lbs.



GRINNELL LIGHT WEIGHT CONCRETE INSERT (Steel), FIG. 285 — 1. Designed for light-duty use in concrete 2 inches and thicker 2. Arched flanges take reinforcing rods 3. Knockout seals out concrete 4. Full 2 inch lateral adjustment 5. Supports up to 400 lbs.

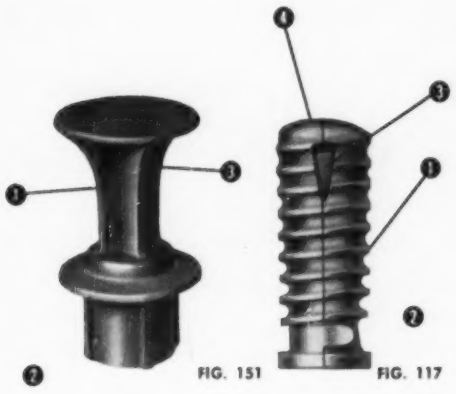


FIG. 151 FIG. 117

GRINNELL SCREW CONCRETE INSERT (Malleable Iron), FIG. 151 — 1. Malleable iron for extra strength 2. Pipe sizes through 12 inches. 3. Supports up to 2,120 lbs. **GRINNELL EXPANSION CASE (Malleable Iron), FIG. 117** — 1. Malleable iron, cadmium plated, assures high resistance to impact, corrosion 2. Pipe sizes through 16 inches 3. Rod moving upward forces wedge-shaped nut downward, expanding and locking case in concrete 4. Supports up to 1300 lbs.

GRINNELL CB "Closed Back" CONCRETE INSERT (Malleable Iron), FIG. 282 — 1. One body size accommodates 5 sizes of rods 2. Slot takes reinforcing rods to assure maximum load rating. 3. One-piece body prevents concrete seepage 4. Teeth on insert and nut hold rod firmly in place 5. Homogeneous composition of malleable iron throughout 6. Supports up to 1430 lbs. (Also available in smaller "CB-JUNIOR" size that supports up to 770 lbs.)

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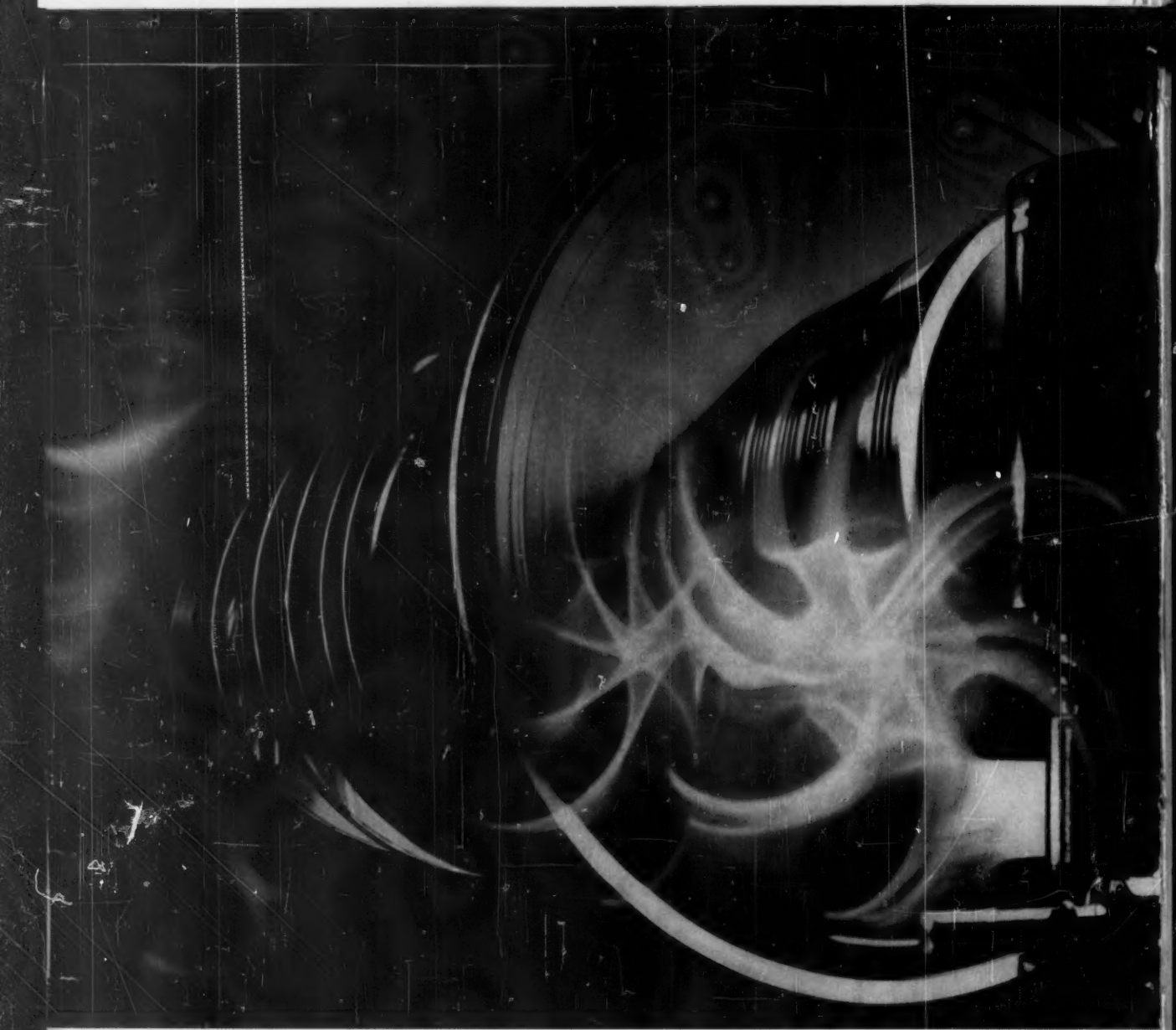

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